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Pollution	Propane	Pollution Control	13B	
Halocarbons	Butanes	Stationary Sources	07C	
Ozone	Packaging	Chlorofluorocarbons	07B	13D
Stratosphere			04A	
Ultraviolet Radiation			20F	
Aerosols			07D	
Hydrocarbons				

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Final Report

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NOTICE

This document has been reviewed in accordance with U.S. Environmental Protection Agency policy and approved for publication. Mention of trade names or commercial products does not constitute endorsement or recommendation for use.

ABSTRACT

Because stratospheric ozone provides protection from biologically damaging ultraviolet-B radiation, and because chlorofluorocarbons (CFCs) have been strongly implicated in the thinning of the Earth's stratospheric ozone layer, there is an urgent need to eliminate production and use of the CFCs. In the United States, CFCs were banned for use as propellants from nearly all aerosol products as early as 1978. In place of the CFC propellants, liquified hydrocarbons such as propane, n-butane, and isobutane were found to be acceptable substitutes for the majority of aerosol products. This report is intended to provide technical assistance to aerosol product marketers and fillers in other nations now faced with eliminating CFCs under the terms of the Montreal Protocol. The report addresses the issues of hydrocarbon propellant supply, product reformulation, equipment conversion, and safety concerns for both the manufacturing plants and the aerosol products themselves.

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SECTION 1

INTRODUCTION

BACKGROUND

Recent concern about depletion of the stratospheric ozone layer has focused on synthetic chemicals known as chlorofluorocarbons (CFCs). These compounds have been used for many years in many products because of their desirable properties: CFCs are nonflammable, relatively nontoxic, and inexpensive. Historically, most CFCs have been used in refrigerants, solvents, blowing agents, insulating gases, and aerosol propellants. Scientists have concluded, however, that destruction of the ozone layer by CFCs will allow too much harmful ultraviolet radiation to reach the Earth's surface, with potentially catastrophic results. The most serious consequences include a higher incidence of skin cancer and cataracts, suppression of the human immune system, damage to plant and animal life, and global warming.

In response to these concerns, countries around the world have agreed to phase out the production of CFCs by the year 2000. The Montreal Protocol, drafted under the auspices of the United Nations Environment Programme (UNEP), has been ratified as of October 1990 by 68 countries and the European Economic Community (EEC) (1). Work is now underway to find substitutes and alternatives to replace CFCs, as well as to decrease CFC emissions in those areas for which substitutes are currently unavailable.

CONVERSION TO HYDROCARBONS

Many options exist for replacing the CFC-propelled aerosol package. This manual does not try to discuss the strengths and weaknesses of the many potential options. A brief list of these options, however, follows:

- Hydrocarbon propellants. Hydrocarbon propellants are primarily mixtures (or pure components) of butane and propane, along with pentane and, to a much lesser extent, ethane. Advantages of hydrocarbon propellants include the fact that they can be treated and blended to obtain the physical and chemical properties that make them suitable aerosol propellants; most hydrocarbons are essentially nontoxic, making them suitable for use in a variety of personal care and household products; hydrocarbon propellants are less expensive than CFCs, enabling manufacturers to produce aerosols at a lower unit cost; and hydrocarbons are compatible with properly selected container materials and formulations, thus preserving shelf life and product stability. Disadvantages are that hydrocarbon propellants are flammable and therefore require special precautions by producers, distributors, and end-users; and they are VOCs, and thus contribute to smog formation. In some urban areas where smog formation is a health and environmental problem, regulations have been proposed to reduce the amounts of VOCs in consumer products. Since the banning of CFC aerosol propellants, hydrocarbons have become the dominant aerosol propellant in many developed and developing countries, and useful experience is available that can minimize the conversion cost for other countries.

- Other liquified gas propellants, such as dimethyl ether (DME). DME is widely used in European and Japanese products. The advantages of DME include solvency and ease of reformulation to water-based products. Disadvantages include its flammability: filling lines and storage facilities must be designed to safely use flammable gas. Also, DME is a volatile organic compound (VOC) which is a smog precursor. Finally, DME is more expensive than the aerosol-grade hydrocarbons.

- Compressed gas propellants such as carbon dioxide, nitrous oxide, and nitrogen. These account for approximately 5 to 10% of aerosol fillings in the U.S. The advantages of compressed gas propellants are low cost and insensitivity to low temperatures, which is important for refrigerated whipped toppings and automotive products, such as engine starter spray and windshield de-icer, used in cold weather. The primary disadvantages of these propellants are the deterioration of spray pattern as the product is used, the limited reservoir of propellant, and the need for specially designed filling equipment (impact gassing, or saturation tower).

- Hydrochlorofluorocarbons (HCFCs) such as HCFC-22, HCFC-123, or HCFC-142b. These compounds, some of which are nonflammable, contribute substantially less to ozone depletion and do not contribute to ground-level smog formation. These propellants are being used in developed countries to a limited extent. Their main limitation is high cost. HCFC-22 and HCFC-142b are already available; however, some of these compounds are difficult to synthesize and are only now beginning to enter commercial production. In June 1990, the parties to the Montreal Protocol met in London to discuss further restrictions on CFCs. The London Amendments included a non-binding declaration that HCFCs should only be used as temporary substitutes for fully halogenated CFCs, and that all countries should voluntarily phase out HCFC production between 2020 and 2040.

- Hydrofluorocarbons (HFCs) such as HFC-152a and HFC-134a. These compounds, some of which are nonflammable, do not contribute to ozone depletion because they do not contain any chlorine and do not contribute to ground-level smog formation. These propellants are being used in developed countries to a limited extent.

- Non-aerosol packaging such as mechanical finger pumps, trigger sprayers, or other alternative packaging. Some of these products compete side-by-side with aerosol products. In many instances, this simple packaging is widely preferred by consumers because of its ease of use, economy, and ecological advantage, regarding destruction of stratospheric ozone.

If manufacturers choose to continue to use aerosol dispensers instead of non-aerosol alternatives, hydrocarbon propellants are the most feasible near-term alternative to CFC aerosol propellants. This manual provides manufacturers of CFC aerosol products with the technical information that will enable them to convert from CFC propellants to hydrocarbon propellants.

ORGANIZATION OF THE MANUAL

This manual is divided into six sections. Section 1 is the Introduction. Section 2 discusses the availability of hydrocarbon propellants, and includes subsections on their physical properties, raw material supply, processing required to remove objectionable odors, and importing. Section 3 covers safety issues, including a discussion of the applicable codes for the safe storage of hydrocarbon gases. Section 4 presents a description of the required equipment modifications and estimated costs for converting a filling line to hydrocarbons. Section 5 briefly describes the requirements for safely storing aerosol products in warehouses or distribution centers. Section 6 discusses the process of reformulating aerosols to use hydrocarbon propellants. Finally, the appendices contain A) a list of aerosol industry experts, B) sample calculations for LPG purification, C) a safety checklist for using hydrocarbon propellants, D) reference ordering information, E) the U.S. Federal Register methods for flame testing, F) a hydrocarbon guide, G) metric conversion factors, and H) approximately 70 formulations of aerosol products that predominantly use hydrocarbon propellants.

SECTION 2

AVAILABILITY OF HYDROCARBON PROPELLANTS

PROPELLANT CHARACTERISTICS AND PHYSICAL PROPERTIES

A replacement aerosol propellant must have the properties that allow an aerosol package to function: 1) the propellant must provide the pressure to expel the product from the container; 2) the propellant may serve as a solvent to help keep the active ingredients in solution; and 3) the propellant must vaporize after leaving the container, producing a spray or foam. Other important properties of aerosol propellants are toxicity, stability, density, and flammability (2). Table 1 compares the properties of the most common CFC propellants (CFC-11 and CFC-12) and the hydrocarbon propellants (isobutane, n-butane, and propane).

Either liquified gas or compressed gas propellants can provide pressure to expel product from the container. Hydrocarbon and CFC aerosol propellants are both liquified gases. Throughout the life of the aerosol product, they generally provide a uniform internal pressure. This is possible because the liquid propellant acts as a "reservoir" of gas to maintain the pressure in the headspace even as the headspace volume increases. With a compressed gas propellant, the pressure will drop as the product is used (2).

The solubility of the propellant is important, since it determines whether the overall contents are uniformly blended ("homogeneous") or whether the contents exist in separate phases ("heterogeneous"). The hydrocarbon compounds are all nonpolar, which renders them insoluble with many polar solvents (including water). However, in some cases, co-solvents such as ethanol can be used to provide single-phase blends of hydrocarbons, alcohol, and water (3). Some heterogeneous hydrocarbon-propelled aerosols require shaking before use (to generate a temporary emulsion that becomes a spray or foam on discharge). Other hydrocarbon-propelled aerosols are anhydrous

TABLE 1. PHYSICAL PROPERTIES OF CFC AND HYDROCARBON PROPELLANTS

Name	Formula	Molecular Weight	Vapor Pressure @21°C (kPa)	Specific Gravity	Solubility in Water (Kauri-Butanol)	Toxicity (TLV)	Stability (g/L per year) (w/steel 30°C, 101.3 kPa)	Flammability (explosive range)
CFC-11	CCl_3F	137.4	89	1.476	60	1000	10	Nonflammable
CFC-12	CCl_2F_2	120.9	586	1.311	18	1000	0.8	Nonflammable
Propane	C_3H_8	44.1	855	0.5077	15.2	1000	--	Flammable (2.18 - 9.5 vol %)
Isobutane	C_4H_{10}	58.1	317	0.5631	17.5	800 (est.)	--	Flammable (1.86 - 8.5 vol %)
N-butane	C_4H_{10}	58.1	221	0.5844	19.5	600	--	Flammable (1.86 - 8.5 vol %)

Source: (2,3)

(containing no water) and may be homogeneous. Finally, surface-active agents can be added to provide stability to the blend (2).

The toxicity of propellants may be compared by using the threshold limit value (TLV, a trademark of the American Conference of Governmental Industrial Hygienists--ACGIH). The TLV is the maximum level that a person working 8 hours a day, 40 hours a week throughout a normal working career can be exposed to a given compound without incurring adverse health effects. Table 1 shows occupational exposure guidelines for CFC-11, CFC-12, and hydrocarbon propellants; they are roughly comparable. A TLV® of 1000 ppm is the highest value listed by ACGIH (lowest toxicity).

The corrosion properties of propellants may be compared by testing their hydrolytic stability. These tests measure the rate of hydrolysis (decomposition) in the presence of a steel test coupon in water (grams hydrolyzed per liter of water per year). As seen in Table 1, the two CFCs are less stable than the pure hydrocarbons. Contaminants in "field-grade" hydrocarbons, however (e.g., water, and sulfur compounds), may have a major effect on corrosion. Hydrocarbon propellant purification will be discussed in a later subsection.

No discussion of the properties of hydrocarbons would be complete without considering flammability. The flammability of an aerosol spray is a combined function of the composition of the product inside the container and of the design of the valve (4). Frequently, other major ingredients of the formula (e.g., alcohols or petroleum distillates) are also flammable (3). A more detailed discussion of aerosol safety appears in Section 3.

LPG AND PROPELLANT SOURCES

Hydrocarbon propellants are derived from liquified petroleum gases (LPG). LPG comes from the ground as a constituent of wet natural gas or crude oil or as a by-product of petroleum refining (5). Table 2 lists the LPG or natural gas liquids (NGL) plants currently operating or under construction in non-communist countries outside of the U.S. as of 1989 (6,7,8). In areas where LPG may be in short supply, processes are available to hydrocrack

TABLE 2. LIST OF LPG AND NGL FRACTIONATION PLANTS OPERATING OR UNDER CONSTRUCTION IN NON-COMMUNIST COUNTRIES

Country	Current LPG Plants			Future LPG Plants (Planned or Under Construction)		
	Raw NGL or LP-Gas Mix	Fractionation	Current Total	LPG/NGL Recovery	Fractionation	Future Total
Algeria	2	0	2	0	0	0
Argentina	0	5	5	2	0	2
Australia	1	3	4	0	0	0
Austria	1	0	1	0	0	0
Bahrain	0	1	1	0	0	0
Bolivia	1	1	2	1	0	1
Brazil	10	0	10	0	0	0
Brunei	0	1	1	0	0	0
Canada	117	47*	164	1	1	2
Chile	0	2	2	0	0	0
Columbia	3	2	5	1	0	1
Ecuador	2	0	2	1	0	1
Egypt	6	0	6	3	0	3
France	0	1	1	0	0	0
Greece	1	0	1	0	0	0
Hungary	3	2	5	0	0	0
India	15	0	15	4	0	4
Indonesia	5	2	7	2	0	2
Iran	0	0	0	2	0	2
Italy	1	0	1	0	0	0
Kuwait	0	3*	3	0	0	0
Libya	3	0	3	1	0	1
Malaysia	0	2	2	0	0	0
Mexico	10 C_{2+}	0	0	0	0	0

(Continued)

TABLE 2. (Continued)

Country	Current LPG Plants			Future LPG Plants (Planned or Under Construction)		
	Raw NGL or LP-Gas Mix	Fractionation	Current Total	LPG/NGL Recovery	Fractionation	Future Total
New Zealand	1	1	2	0	0	0
Norway	1	1	2	0	0	0
Oman	3	1*	4	0	0	0
Pakistan	1	0	1	0	0	0
Peru	0	1	1	0	2	2
Qatar	0	2	2	1	0	1
Saudi Arabia	1	3	1	0	0	0
Sharjah	0	1	1	0	0	0
Taiwan	1	2	3	0	0	0
Thailand	2	0	2	1	0	1
United Kingdom	1	2	2	1	0	1
Venezuela	9	5*	14	0	0	0

* Numbers include transfers from other plants.

Source: Reference (6,7,8).

heavier naphthas to propane and butane [e.g., the LPG Unibon® process licensed by UOP (Des Plaines, IL)]. LPG usually refers to a mixture of propane and butane, although other hydrocarbons may also be present (ethane at the light end and pentanes at the heavy end). Table 3 shows the plant feed and "Field Grade" analyses for one Canadian gas plant (3). Table 4 presents the U.S. Gas Processors Association specifications for the LPG products: commercial propane, butane, and butane-propane mixtures (9). LPG is generally in high demand because of its use as a feedstock for petrochemical plants or refineries. The feedstock use of LPG is divided between a portion sent to cracking furnaces to produce ethylene (some of which ultimately ends up as polyethylene plastic) and a portion further distilled to separate propane from butanes (the butanes are later isomerized to isobutane which is reacted to make a high-octane alkylate gasoline blending component). One of the popular technologies for the isomerization of n-butane to isobutane is the Butamer® process [licensed by UOP (10)]. LPG is also sold as a fuel for heating (industrial, commercial, and residential), and for direct motor fuel in special applications (5). Figure 1 is a chart showing world exports of LPG in 1988.

The amount of LPG used for aerosol propellants is very small (less than 0.1 percent in the U.S. in 1981) (3). Aerosol grade hydrocarbon propellants are prepared by first distilling the LPG to separate the various species. Distillation separates the components of a solution using repeated vaporization and condensation (13). The degree of separation is essentially limited by the amount of heat energy that must be supplied. Figure 2 is a schematic diagram of a distillation system to separate propane and butane (depropanizer) followed by separation of the isobutane from normal butane (C_4 splitter). Hydrocarbon propellant blends of varying vapor pressure are formulated as shown in Table 5 (14), and the specifications for aerosol grade hydrocarbons from several U.S. vendors are listed in Table 6 (3). The distillation of hydrocarbon propellant is normally carried out at a specially designed plant that serves the regional aerosol industry. These plants are generally quite sophisticated and would be too large for any single aerosol filler.

Some aerosol products may use the so-called "natural blend" LPG instead of distilled hydrocarbons. According to one source, natural blend LPG, obtained by a coarse distillation of natural gas liquids (de-ethanized and

TABLE 3. RAW PLANT FEED AND FIELD GRADE ANALYSES (WEIGHT PERCENT)

Ingredients	Plant Feed	Field Grade Propane	Field Grade Isobutane	Field Grade Normal Butane
Methane	0.05	0.1	0.01	0.01
Ethane	1.7	2.9	0.03	0.02
Propane	50.3	94.9	2.4	0.4
Isobutane	9.8	2.0	96.2	1.9
n-Butane	17.3	0.1	1.3	96.0
Isopentane	5.0	0	0.05	1.9
n-Pentane	4.6	0	0.03	0.2
Hexanes, etc.	11.3	0	0	0
Unsaturated Hydrocarbons	0.03	0	0	0
Sulfur Compounds	trace	trace	trace	trace
Water	trace	trace	trace	trace

Typical month, at Dome Petroleum Ltd. Sarnia, Canada.
Source: Reference (3)

TABLE 4. U.S. GAS PROCESSORS ASSOCIATION LPG SPECIFICATIONS

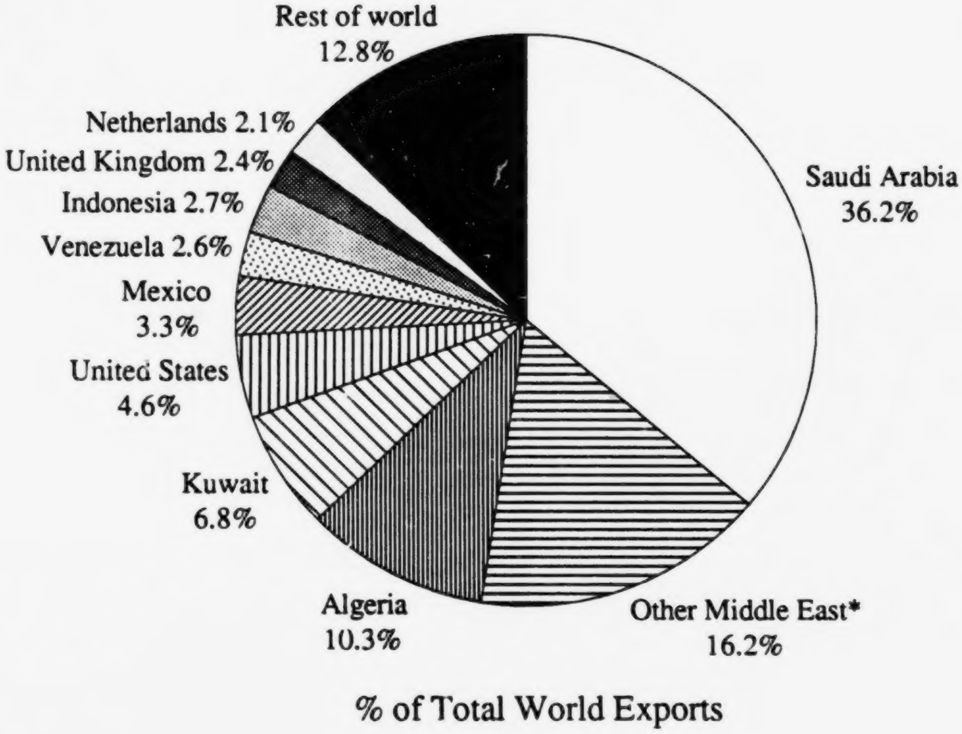
Product Characteristics	Commercial Propane	Commercial Butane	Commercial B-P Mixtures
Composition	Predominantly propane and/or propylene.	Predominantly butanes and/or butylenes.	Predominantly mixtures of butanes and/or butylenes with propane and/or propylene.
Vapor Pressure at 38°C, kPa max.	1535	584	1535
Volatile Residue:			
max. temperature at 95% evaporation	-38°C	2.2°C	2.2°C
butane and heavier, liquid volume percent max.	2.5	--	--
pentane and heavier, liquid volume percent max.	--	2.0	2.0
Residual matter:			
residue on evaporation of 100 ml, max.	0.05 ml	--	--
oil stain observation[a]	pass	--	--
Corrosion, copper strip, max.[b]	No. 1	No. 1	No. 1
Volatile sulfur, grains per 100 cu. ft., max.	15	15	15
Moisture content[c]	pass	--	--
Free water content	--	none	none

Source: Reference (9,11).

[a] An acceptable product will not yield a persistent oil ring when 0.3 mL of solvent residue mixture is added to a filter paper, in 0.1 mL increments and examined in daylight after two minutes, as described in ASTM Test Method D2158.

[b] The copper strip exposed to the liquefied petroleum gases is compared to the ASTM copper strip corrosion standards described in ASTM Test Method D1838.

[c] The moisture content will meet the valve freeze test ASTM Test Method D2713.



*Includes United Arab Emirates, Bahrain, Qatar, Iran, Iraq

Figure 1. World exports of refined LPG (1988).

Source: Reference (12)

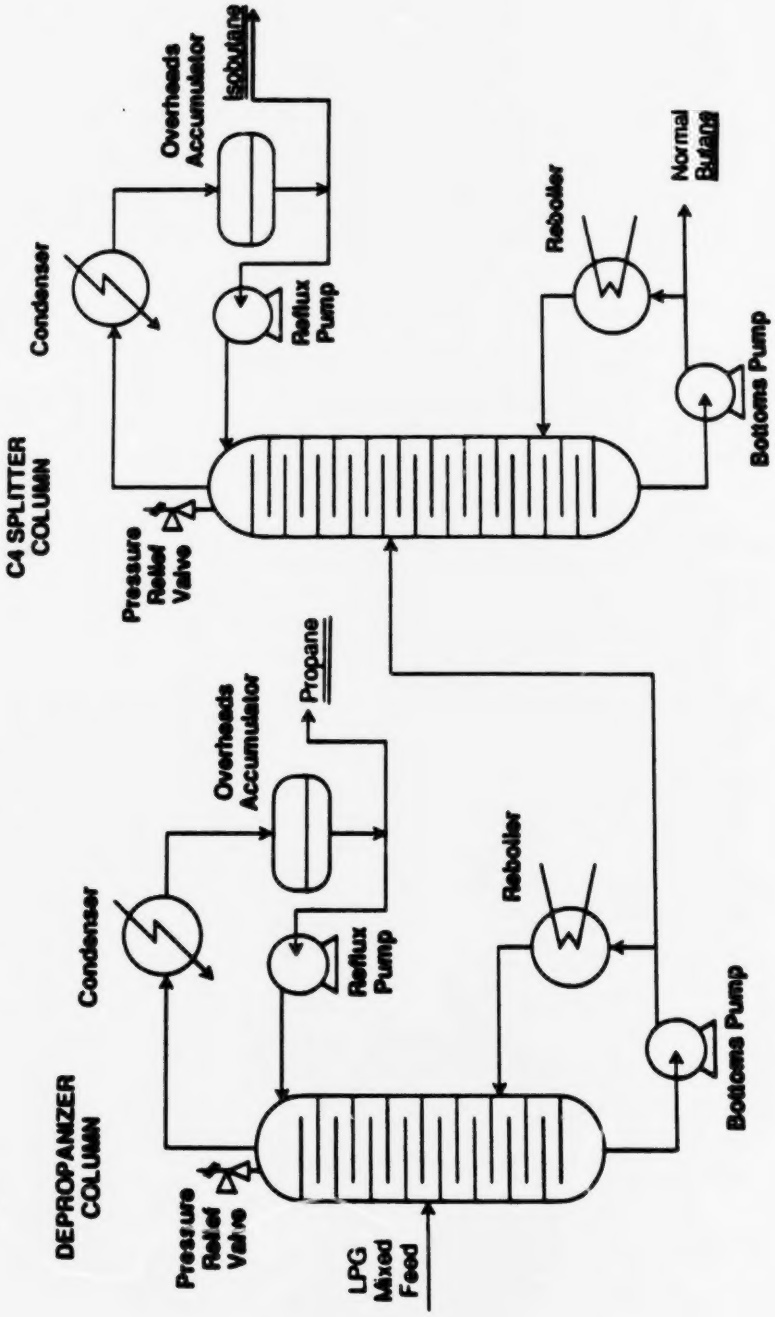

DEPROPANIZER COLUMN
Pressure Relief Valve
LPG Mixed Feed
Condenser
Overheads Accumulator
Propane
Reflux Pump
Reboiler
Bottoms Pump
C4 SPLITTER COLUMN
Pressure Relief Valve
Condenser
Overheads Accumulator
Isobutane
Reflux Pump
Reboiler
Normal Butane
Bottoms Pump

Figure 2. Distillation train.

TABLE 5. APPROXIMATE COMPOSITION OF SEVERAL HYDROCARBON PROPELLANT BLENDS

Propellant Name[a]	Pressure at 21°C (kPa)	Composition	
		Compound	Weight %
A-31	315	Isobutane	100
A-40	377	Propane Isobutane	10 90
A-46	418	Propane Isobutane	16 84
BIP-55	480	Propane Isobutane n-Butane Pentane	32 27 39 3
A-60	515	Propane Isobutane n-Butane	32 66 2
A-70	584	Propane Isobutane	43 57
A-85	689	Propane Isobutane	63 37
A-108	648	Propane	100

[a] "A" type designations are trademark of Phillips Petroleum Company.

Source: Adapted from Reference (14).

TABLE 6. SPECIFICATIONS FOR AEROSOL GRADE HYDROCARBON PROPELLANTS

Property	Aeropres			Diversified			Phillips		
	Propane	Isobutane	n-Butane	Propane	Isobutane	n-Butane	Propane	Isobutane	n-Butane
Purity-Wt. % (minimum)				95	95	95			
Purity-Mol. % (minimum)	95	95	95				98	95	97
Pressure (kPa)									
21.1°C (70°F)	859	315	218	846	315	218	846	315	218
38°C (100°F)				1287	508	356			
54°C (130°F)				1873	770	563			
Initial Boiling Point (°C)				-43	-12.7	-2.2			
Dry Point (°C)				-41	-9.4	0.5			
Flash Point (°C)				-104	-83	-74			
Specific Gravity of Liquid (15°C)				0.508	0.563	0.584			
Moisture (ppm) (maximum)	25	25	25	<5	<5	<5			
Sulfur (ppm) (maximum)	5	5	5	<1	<1	<1	5	5	5
Unsaturates (ppm) (maximum)	10	10	10						
Residue (g/100 ml) (maximum)	0.0005	0.0005	0.0005	0	0	0	0.0005	0.0005	0.0005
Total Saturated Compounds (w%)				>99.9	>99.9	>99.9	>99.9	>99.9	>99.9
Acidity of Residue	Neut.	Neut.	Neut.				Neut.	Neut.	Neut.
Odor (Panel)	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass	Pass

Source: Reference (3).

partially depropanized), may typically have a composition of approximately 60% n-butane, 20% isobutane, and 20% propane (14). Its primary advantage is that it is less expensive because there is less processing of the hydrocarbon. The natural blend propellant is suitable in products where odor is not as important (where the concentrate itself is quite odorous as in some degreasers or spray paints) or where the spray characteristics are not critical (such as wet sprays in some residual insecticides). A disadvantage of natural blend hydrocarbon propellant is that the quality varies resulting in inconsistent pressure. Because the natural blend is produced by a coarse distillation, the amount of propane, butane, and pentanes may differ from one lot to the next, and this will affect the spray pattern of the finished product. For example, low pressure, due to there being too little propane component, could theoretically be adjusted by the filler at the point of manufacture. However, this would require either a separate gassing step to adjust the pressure or propellant blending facilities.

Natural blend hydrocarbon propellants are likely to contain larger quantities of impurities (such as water, sulfurous compounds, olefins, or reactive particulates). For example, the water content in commercial propane is typically 350 parts per million weight (ppmw) or less (equivalent to a dew point of -26°C) (15). This is much higher than the water content of aerosol grade hydrocarbon propellant, which Table 6 shows to be between 5 ppmw and 25 ppmw (equivalent to dew points of -54 to -66°C). The presence of water can be tolerated in water-based products, but not in products intended to be anhydrous. The removal of these impurities is discussed in the following section.

PURIFICATION PROCESSES

Some types of aerosol products require a purer hydrocarbon propellant than other types. The most demanding aerosol products are aerosol perfumes and fragrances. Other products which require a highly refined hydrocarbon propellant include personal care products, food products, medicinal or pharmaceutical products, some household products, certain paints and coating sprays, and certain automotive and industrial sprays.

Before the propane and butanes are suitable for these aerosol propellant applications, they must be purified further to remove odorous and reactive compounds such as unsaturated hydrocarbons (for example, 1-butylene or propylene), as well as sulfur compounds and water (3). The processes used include:

- Dehydration (for removing moisture);
- Acid gas removal (for removing sulfur compounds); and
- Sulfuric acid treatment or desiccant treatment (to remove unsaturated compounds).

Purification of the hydrocarbon propellant is proprietary, since each producer may have unique processing techniques. The processes selected depend on the level of contamination and on the scale of processing. Table 7 presents the relative merits of various processes employed in large-scale LPG purification (9). Contacts with industry experts and limited published data suggest that the most common type of hydrocarbon propellant purification is the solid adsorbent process. The remaining processes listed in Table 7 are certainly applicable to the refinery, petrochemical, and gas processing industries, but it is unclear to what extent they are appropriate for hydrocarbon propellant purification. The following discussion will therefore focus on the use of various adsorbents for LPG purification. A schematic of an on-site propellant purification process installed at a large (15-million-unit-per-year) aerosol production plant in Egypt (16) is shown in Figure 3.

The solid adsorbent process can involve the use of such materials as silica gel, activated aluminas, or molecular sieve adsorbents for water or sulfur compounds (dehydration and acid gas removal). Unsaturated compounds can be removed using activated carbon or molecular sieves. The process shown in Figure 3 is a nonregenerable system, and could be appropriate for a large filling plant with a hydrocarbon propellant supply of variable quality. The disadvantage of this type of plant, however, is that the adsorbent must be periodically replaced. Once the adsorbent becomes saturated, the impurities will no longer be removed, and contaminated propellant will enter the system.

TABLE 7. MERITS OF SEVERAL LPG TREATING PROCESSES

1. Molecular Sieves Treating
    - A. Can handle large or small streams with equal facility.
    - B. Reduces total sulfur content by removing hydrogen sulfide, mercaptans, or other organic sulfur in the same adsorber vessel.
    - C. Will produce copper-strip, doctor sweet product[a,b].
    - D. Will dry in the same step without additional equipment.
    - E. Requires that plant fuel supply be made slightly sour by use of this stream to strip sulfur compounds from the molecular sieve. (Only applies if regenerated on site.)
2. Regenerative Caustic (10% NaOH in Packed Column)
    - A. Handles a large volume of hydrocarbon.
    - B. Primarily for removing methyl and ethyl mercaptans.
    - C. Capable of producing a "doctor sweet" product[b].
    - D. Reduces the total sulfur content of treated product.
3. Solid Potassium Hydroxide Treatment
    - A. Low installation and operating costs.
    - B. Acts as a desiccant as well as removing the sulfur compounds.
4. Merox® Treating[c]
    - A. Can handle large or small streams with equal facility.
    - B. Eliminates problem of disposing of spent phenolic caustic.
    - C. Product is sweet when it leaves unit; no holding period is required.
    - D. Adds problem of sulfur compounds from regenerated air leaving the regenerator.

---

[a] "Copper-strip" refers to ASTM Test Method D1838 to test for corrosion by LPG.

[b] "Doctor sweet" refers to a low-sulfur content, as measured by the Doctor Test for sulfur using sodium plumbite.

[c] Merox® is a trademark of UOP (Des Plaines, IL).

Source: Reference (9).

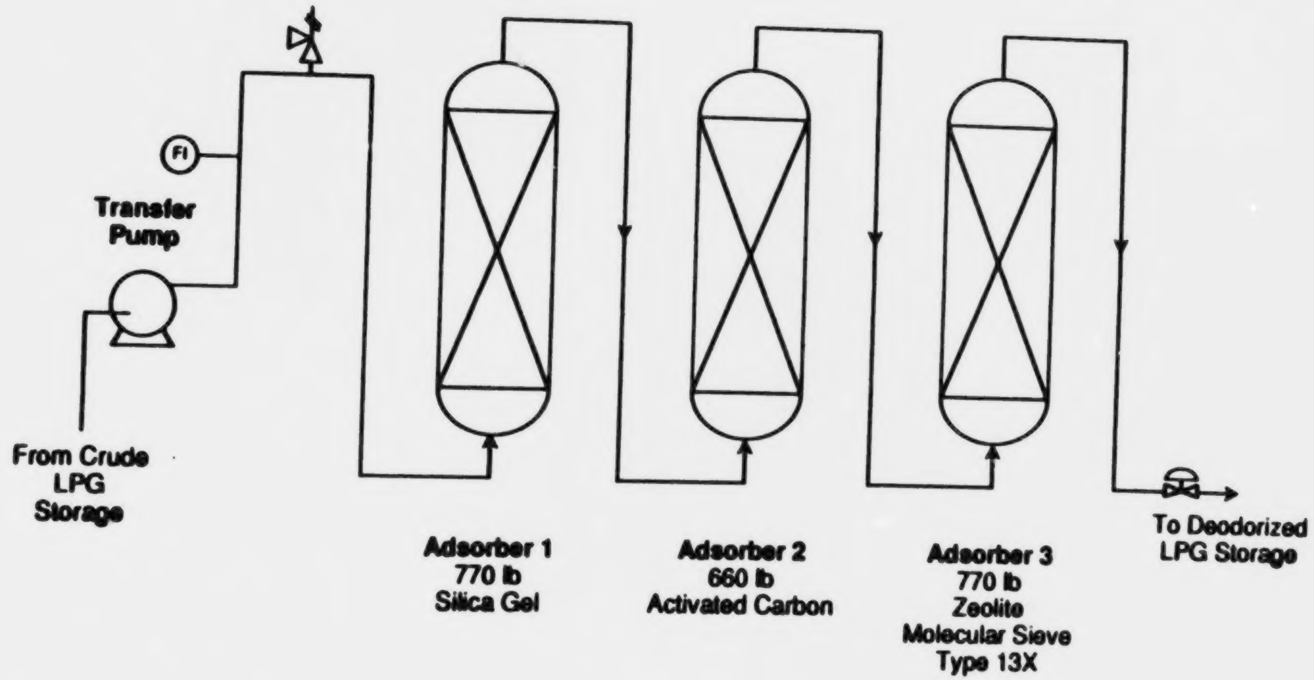

FI
Transfer Pump
From Crude LPG Storage
Adsorber 1
770 lb
Silica Gel
Adsorber 2
660 lb
Activated Carbon
Adsorber 3
770 lb
Zeolite
Molecular Sieve
Type 13X
To Deodorized LPG Storage

Figure 3. Purification train (16).

If the "breakthrough" point is not detected promptly, the quality of the aerosol propellant would be jeopardized.

Appendix B contains example calculations for a dehydration/desulfurization system using two nonregenerable beds for the purification of LPG. The example case is for a large-size automated filling plant producing 10 million cans per year. These calculations include several "worst-case" assumptions that may not hold true in many cases (i.e., saturated water content and greater than 90 ppmv H_2S content), but they nevertheless suggest that annual costs for adsorbent change-out could range as high as $50,000 per year (or $0.016 per kg of LPG processed). This calculation assumes that the spent adsorbent has no residual value and does not include the amortization of fixed equipment (such as pumps, surge vessels, and adsorber vessels).

An alternative to on-site purification is to use a central purification facility in conjunction with the distillation system described previously. The central purification facility can operate with multiple adsorbent beds that can be alternated between purification (on-line) and regeneration (off-line). This type of system is large enough to serve for several large aerosol filling plants. Together with a source of LPG and a distillation system, the purification system completes the basic elements needed for a regional hydrocarbon propellant supply.

The science of purifying hydrocarbon compounds using solid adsorbents has been studied extensively. Purification of hydrocarbon propellants is one specific application of this technology. Regenerable solid adsorption facilities for hydrocarbon purification are commonly used in natural gas processing plants (cryogenic type) to avoid the formation of solid hydrates. Similar processes are often found in the pretreatment of hydrocarbon streams to avoid catalyst poisoning in many petrochemical processes. Additional technical information on purifying hydrocarbons with adsorbents is available from adsorbent suppliers such as those listed in Appendix A.

IMPORTING PROPELLANTS

Countries importing purified hydrocarbon propellant instead of producing it from native LPG supplies can transport the hydrocarbon propellants by land or by sea. To transport overland, the country must have a highway or railroad system capable of handling a large tractor-trailer rig or railcar load of propellant and the source of supply must be close enough to ship overland directly (such as from the U.S. to Mexico). The costs of the two methods are similar.

To ship hydrocarbon propellant by ocean, the importing country has two options: International Organization of Standardization (ISO) Containers and Tank Trailers. ISO containers are available in sizes up to 22,700 liters (6,000 gallons) (water capacity); older versions were limited to roughly 17,000 liters (4,500 gallons) (water capacity). The actual shipment volume is limited to 80% of the water capacity. These containers are fitted into specially braced steel frames, and are rigged so that they can be stacked on a containerized cargo ship. Because they can be stacked just the same as a standard 20-foot container, they are charged a lower rate. Unloading ISO containers at the port of entry requires "Ocean Service." A port with ocean service has large dock cranes to transfer containers on and off the dock and ship. The ISO container contents can either be transferred by pumping from the container into a road tanker at the port, or the container can be transported on a low-boy chassis trailer.

Tank trailers have a capacity of up to 37,850 liters (10,000 gallons) (water capacity), or an effective product capacity of about 30,280 liters (8,000 gallons). Since the tank trailer cannot be stacked and therefore takes up more deck space, it is charged a higher rate for shipment. The tank trailer can be driven on and off of a special cargo ship known in the trade as a "Roll-on/Roll-off" ship. These vessels are often used for transporting automobiles, and special ramped dock facilities are required.

Appendix A provides a list of suppliers who will export hydrocarbon propellants.

SECTION 3

SAFETY WHEN USING HYDROCARBON PROPELLANTS

GENERAL SAFETY

Hydrocarbon gases are used primarily as fuels. Because of their flammability, they must be handled with great care. This section focuses on the properties of hydrocarbons that relate to potential explosion and fire hazards and on the engineering of safe aerosol-filling operations.

In the U.S., the National Fire Protection Association (NFPA) has issued standards for manufacturing and storing aerosol products (NFPA Code 30B, Reference 17) and for storing and handling LPG (NFPA Code 58, Reference 18). In addition to these codes, which relate directly to the safety of aerosol products, there are references to many other relevant NFPA codes. Table 8 lists all the NFPA standards relevant to the handling of hydrocarbon propellants (17). The NFPA Codes do not apply to aerosol products that contain a nonflammable base product and a nonflammable propellant (for example, aerosol whipped cream contains a water-based base product and the propellant is nitrous oxide, which is a nonflammable). The "base product" is synonymous with "concentrate," which consists of the active ingredients and the solvents.

NFPA Code 30B covers manufacturing, warehouse storage (both in-plant and distribution), and the storage and display of aerosols in stores selling aerosol products. The first topic (manufacturing) is discussed in this section; safety issues relating to warehouse storage, sales display, and backstock storage are covered in Section 5.

A primary focus of NFPA 30B in the manufacturing area is to ensure the safety of propellant storage areas ("Tank Farms") and propellant gassing rooms ("Gas Houses"). Appendix C contains a safety checklist for aerosol fillers using hydrocarbons. Safety measures include the following:

TABLE 8. NFPA CODES RELEVANT TO AEROSOL PRODUCTION, STORAGE, AND DISTRIBUTION

1.	Primary Codes:	
	NFPA 30B-1990	Manufacture and Storage of Aerosol Products
	NFPA 58-1989	Standard for the Storage and Handling of Liquefied Petroleum Gases
	NFPA 70-1990	National Electrical Code (Esp. Articles 500 and 501)
2.	Additional Fire Protection Codes:	
	NFPA 10-1990	Standard for Portable Fire Extinguishers
	NFPA 11-1988	Standard for Low Expansion Foam and Combined Agent Systems
	NFPA 11A-1988	Standard for Medium and High Expansion Foam Systems
	NFPA 12-1989	Standard on Carbon Dioxide Extinguishing Systems
	NFPA 12A-1989	Standard on Halon 1301 Fire Extinguishing Systems
	NFPA 12B-1990	Standard on Halon 1211 Fire Extinguishing Systems
	NFPA 13-1989	Standard for the Installation of Sprinkler Systems
	NFPA 14-1990	Standard for the Installation of Standpipe and Hose Systems
	NFPA 16-1986	Standard on Deluge Foam-Water Sprinkler and Foam-Water Spray Systems
	NFPA 16A-1988	Recommended Practice for the Installation of Closed-Head Foam-water Sprinkler Systems
	NFPA 17-1990	Standard for Dry Chemical Extinguishing Systems
	NFPA 20-1990	Standard for the Installation of Centrifugal Fire Pumps
	NFPA 22-1987	Standard for Water Tanks for Private Fire Protection
	NFPA 24-1987	Standard for the Installation of Private Fire Service Mains and Their Appurtenances
	NFPA 30-1990	Flammable and Combustible Liquids Code
	NFPA 31-1987	Standard for the Installation of Oil Burning Equipment
	NFPA 45-1986	Standard on Fire Protection for Laboratories Using Chemicals
	NFPA 54-1988	National Fuel Gas Code
	NFPA 69-1986	Standard on Explosion Prevention Systems
	NFPA 72-1990	Standard for the Installation, Maintenance, and Use of Protective Signaling Systems
	NFPA 72E-1990	Standard on Automatic Fire Detectors
	NFPA 80-1990	Standard for Fire Doors and Windows
	NFPA 90A-1989	Standard for the Installation of Air Conditioning and Ventilating Systems
	NFPA 101-1988	Life Safety Code
	NFPA 231-1990	Standard for General Storage
	NFPA 231C-1986	Standard for Rack Storage of Materials
	NFPA 505-1987	Fire Safety Standard for Powered Industrial Trucks Including Type Designations, Areas of Use, Maintenance, and Operation
	NFPA 1221-1988	Standard for the Installation, Maintenence, and Use of Public Fire Service Communication System

- Locating manufacturing buildings and flammable propellant storage tanks at a safe distance [7.6 m (25 feet) or more] from the property fenceline and from other areas of the plant that could become sources of ignition or shrapnel.

- Providing for a blast wall between flammable propellant charging rooms and other areas.

- Providing a well-ventilated gas house that gives positive ventilation (at both normal and "emergency" rates).

- Routing all discharge vents from vacuum pumps, propellant pumps, and building ventilation systems no less than 3 m (10 feet) above the roof to ensure adequate dispersion.

- Complying with the 1990 U.S. National Electrical Code (NEC) for hazardous atmospheres, which requires that equipment be isolated so that these potential ignition sources are enclosed in "explosion proof" housings. The NEC Code specifies that approved fixtures be used on electric motors, switches, lamps, and other electrical equipment. The minimum ratings for the gas house and pump room where flammable hydrocarbon propellants are used are Class I, Division 1, Group D. The standard for the flammable propellant DME is slightly more stringent Group C. This usually means that, while much of the equipment can be approved for either propellant, electric motors must be upgraded for DME. Appendix D contains information for ordering the 1990 NEC code.

- Installing blow-out walls or ceiling ("deflagration venting") to allow a controlled release of pressure if an explosion occurs. If venting is not possible or if personnel will be present when filling is underway, a specially engineered "explosion suppression" system is required. This type of system often employs pressurized halon, which is also an ozone-depleting substance. Its production will be phased out under the Montreal Protocol by the year 2000, except for "essential uses" that are yet to be defined.

- Providing automatic sensing systems to measure flammable gas concentrations in the gas house, sound alarms, and activate the "emergency" ventilation system and interlocks to cut off the propellant supply from the tank farm.

Again, this is only a partial list of the Code requirements. Other important areas cover such topics as fire sprinkler systems, standpipes, fire hoses, and fire extinguishers. The interested reader is referred to the complete NFPA Code 30B for a comprehensive list of requirements.

A fully enclosed gas house with two-speed ventilation and an explosion suppression system may not be necessary in warm climates, where an "open-air filling" area may be possible (19). The open-air filling technique has several advantages, such as the reduced capital expenditure for installing or retrofitting an aerosol-filling plant.

Explosion-proof laboratory hoods with adequate face velocity (along with other equipment modifications) may be an appropriate alternative for small, labor-intensive aerosol fillers. These options are discussed in Section 4.

OTHER ENGINEERING SAFETY MEASURES

In addition to the general safety considerations for hydrocarbon storage and building construction, other engineering safety measures apply to the hydrocarbon container valves and accessories, piping, and safety relief devices. The Chemical Specialties Manufacturers Association (CSMA) handbook, Hydrocarbon, Dimethyl Ether, and other Propellants: Considerations for Effective Handling in the Aerosol Plant Laboratory (20) discusses the engineering safety measures for these areas. Appendix D contains information on how to order the CSMA handbook. In general, engineering safety considerations for container valves and containers include the following:

- All valves, fittings, and accessories connected directly to the hydrocarbon storage container, including primary shut-off valves, should have a minimum-rated working pressure of 1824 kPa (250 psig). Materials should be compatible with LPG and should not be cast iron.

- All connections to the container, except for safety relief devices, should have shut-off valves. These valves should be located as close to the container as practical.

- Fixed storage tanks should employ excess-flow valves. These valves will automatically close if the liquid or vapor flow rate exceeds a preset rate. All connections from the excess flow valve should have a rated capacity greater than the excess-flow valve.

General engineering safety considerations for piping include the following:

- Pipe, tubing, and fittings should be able to handle a working pressure of a least 1824 kPa (250 psig). Schedule 80 pipe should be used if the pipe is to be threaded, back welded, or buried. Schedule 40 pipe can be used if joints are to be welded or welded and flanged.

- The valve seat, gaskets, packing, diaphragms, etc., should be made of material that is compatible with the hydrocarbon propellant to be used.

- After assembly, the piping system should be pressure tested at no less than 1824 kPa (250 psig) to check for leaks.

- Flexible connections or expansion loops should be used in long piping runs to minimize expansion, contraction, vibration, and settling.

- The entire piping system, including flanges and valves, should be electrically grounded.

In addition to excess-flow shut-off valves, hydrocarbon storage tanks and piping systems should use other safety relief devices, designed to open at a set pressure to protect the vessel against rupturing under high pressures as a result of fire or other increases in temperature. The safety relief devices are either spring-release devices or rupture discs. In either case, relief devices should be installed on all unobstructed venting. Shut-off valves should not be installed between the storage tank and the relief device.

OTHER SAFETY ASPECTS

In addition to safety issues related to the use of flammable propellants in the gas house and tank farm, other potential hazardous areas must be examined. Many aerosol filling plants use a water bath ("hot tank") to heat the filled aerosol containers in order to raise the pressure and verify container strength or check for leaks. Occasionally, full aerosol containers rupture during this test; therefore, adequate ventilation near the water bath must be available.

Another issue is the possible prohibition of shipments of deodorized ("unstenched") LPG or hydrocarbon gases from producer to end-users. This is a potential regulatory impediment that could require aerosol fillers to install on-site deodorizing facilities--at a cost possibly prohibitive to small undercapitalized operations. In the U.S., shipments of LPG are governed by the Department of Transportation (DOT), which requires that all LPG must be odorized, unless odorization would be harmful to the further processing of the LPG (21). Since odorization would be harmful in the case of most hydrocarbon propellants, unstenched LPG shipments are permitted by DOT.

LABELING REQUIREMENTS AND FLAMMABILITY TESTING

Manufacturers normally place warnings on labels of aerosol products to ensure that the product is used safely and for the intended purpose. Among the most important labeling statements are the words FLAMMABLE and EXTREMELY FLAMMABLE. In the U.S., the Consumer Product Safety Commission (CPSC) requires that these warnings are printed on "household product" aerosols, and the U.S. Environmental Protection Agency (USEPA) requires warnings on insecticide product labels. Products under the jurisdiction of the U.S. Food and Drug Administration (FDA) include hair spray and personal deodorants.

Labeling and Precautionary Statements

"Flammable" precautions normally do not discourage purchases of useful products except on baby products, foods, and some pharmaceuticals. In one controlled test, a run of insecticides labeled CAUTION: FLAMMABLE sold more rapidly than their unmarked counterparts. Products marked EXTREMELY FLAMMABLE are common among aerosol products (such as automotive aerosols). Well over half of all aerosols in the U.S. are now marked FLAMMABLE or EXTREMELY FLAMMABLE. Over 90% contain flammable propellants, and more than two-thirds contain flammable or combustible concentrates (22).

Some flammable aerosol products are dangerous if misused. Overheating is perhaps the most frequent hazard of flammable aerosol products. The second major consumer risk can occur when cans are dropped, causing the valve to malfunction. In some cases, it may be appropriate to describe the severe consequences of not following critical precautions (23). For example, an insecticide product known as a Total-Release Insect Fogger (TRIF) includes the instruction to shut off stove and other appliance pilot lights before use. Serious explosions have occurred in homes as a result of consumers who did not shut off pilot lights or who used more than one can per room. Another potentially dangerous product is an aerosol tire inflator intended to temporarily repair and inflate a punctured automobile tire. If flammable tire inflator products are repeatedly used without deflating and reinflating the tire with air, the HC gas could be concentrated to the explosive range, which could pose an extreme fire hazard when the tire is dismounted from the rim (24).

The standard phrase "Keep Away from Fire or Sparks" is commonly used with flammable aerosols. Examples of other standard precautionary statements include:

- "Always Use with Adequate Ventilation;"
- "Heavy Localized Concentrations of Flammable Vapors May Be Hazardous;" and
- "Do Not Puncture or Incinerate."

Fillers and marketers should ensure that the directions for use are legally complete.

Testing for Flammability

In the U.S., two tests are used to determine when FLAMMABLE or EXTREMELY FLAMMABLE labels are required: 1) the Modified Flash Point Test, and 2) the Flame Projection/Flashback Test. Appendix E contains a copy of the Federal Register official methods (26 FR 191; August 12, 1961).

The Modified Flash Point Test for determining the lowest temperature at which application of the test flame causes the vapor at the surface of the liquid to ignite but not continue to burn (flash). The flash point test used by the CPSC and applied to hydrocarbon-propelled aerosol products has several problems. One is that virtually any aerosol product using a hydrocarbon propellant will be classified as EXTREMELY FLAMMABLE by this test, even if the product contained 99% water and 1% isobutane (3). The EPA version of the Flash Point Test, on the other hand, applies only to the concentrate. As a result, many products tested by the EPA version (concentrate tested) are classified as FLAMMABLE, while the CPSC version classifies the product as EXTREMELY FLAMMABLE. Another limitation of the flash point test is that many products cannot be meaningfully tested. This is because the Modified Flash Point test involves chilling the aerosol contents to -32°C (-25°F), and slowly warming at the rate of 0.8 to 1.4°C per minute. Products containing significant amounts of water cannot be tested in this way because they freeze solid. Likewise, products that separate into liquid phases, become partially solid or viscous, or develop a gel structure cannot be tested; in addition, foams and pastes cannot be tested.

The Flame Projection/Flashback test uses two methods to test the flammability of aerosol products. The Flame Projection test defines the maximum length of the flame at full valve opening. An aerosol will fail the flame projection test if the flame projects more than 457 mm (18 inches) beyond the source at full valve opening. The aerosol will fail the Flashback test if the flame extends back to the aerosol dispenser at any degree of valve opening. The formulator can make several modifications to a product so that it will pass the flame projection test including:

- Reduce the delivery rate;

- Reduce the particle size;

- Add nonflammable ingredients to the concentrate [such as water or chlorinated solvents like 1,1,1-Trichloroethane (which, however, will be phased out by the year 2005 under the Montreal Protocol)]; and

- Replace some of the flammable propellant with nonflammable propellant such as HCFC-22 (22).

One of the most difficult aspects of performing the flashback test is that flashback may be particularly pronounced when the valve is throttled back to very low delivery rates--this despite the fact that aerosol valves are not designed to be throttled down.

Finally, flashpoint and flame projection have essentially no relationship to each other. Materials with low flashpoints and nonflammable propellants can be made to show dramatic flame projection (22). Despite these problems, these tests are still the key methods used for labeling aerosol products in the U.S.

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SECTION 4

EQUIPMENT CONVERSION OF HYDROCARBON FILLING OPERATIONS

Propellant filling operations are classified in three sizes: 1) large operations producing over 2.5 million units per year (automated); 2) medium filling operations producing 0.5 to 2.5 million units per year (manual and/or automated); and 3) small filling operations producing fewer than 0.5 million units per year (manual filling lines).

AUTOMATED FILLING LINES

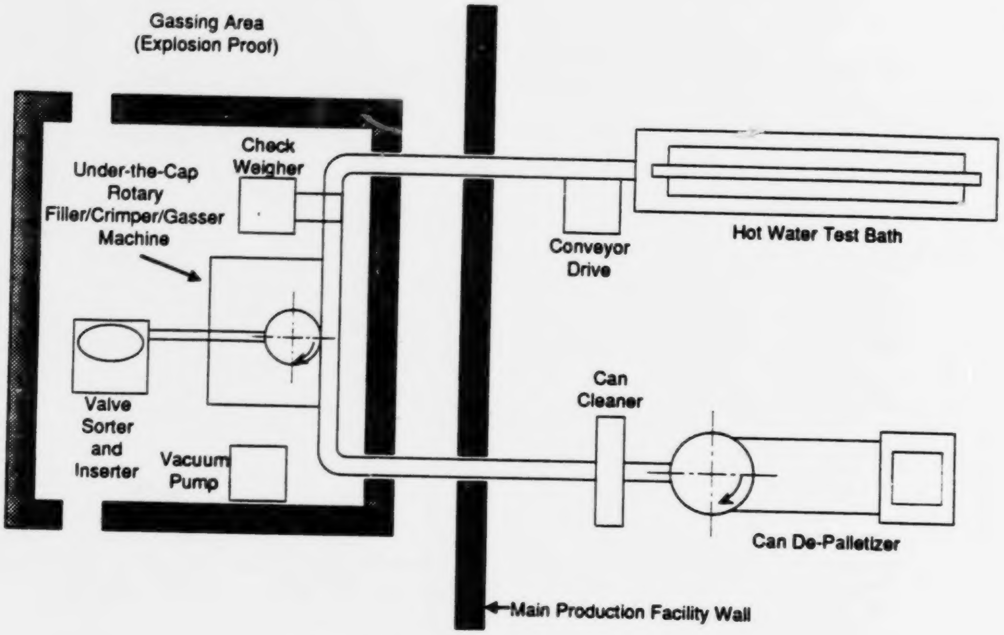
The large aerosol filling operation typically uses an automated production line that can produce 14,000 to 28,000 units per shift, which equals approximately 35 to 70 units per minute. On a basis of 35 units per minute, three 8-hour shifts per day, and a 7-day work week, this type of plant could produce nearly 15 million units per year. Additional operations, such as labeling and packing, may be automated or manual.

Figure 4 illustrates an automated filling line. Table 9 lists the major equipment and production areas, including the base product and blending areas, the propellant supply, and test baths. Table 9 also itemizes possible line modifications. The equipment can be either air-operated or electrical. Each container is mechanically conveyed from one step to the next.

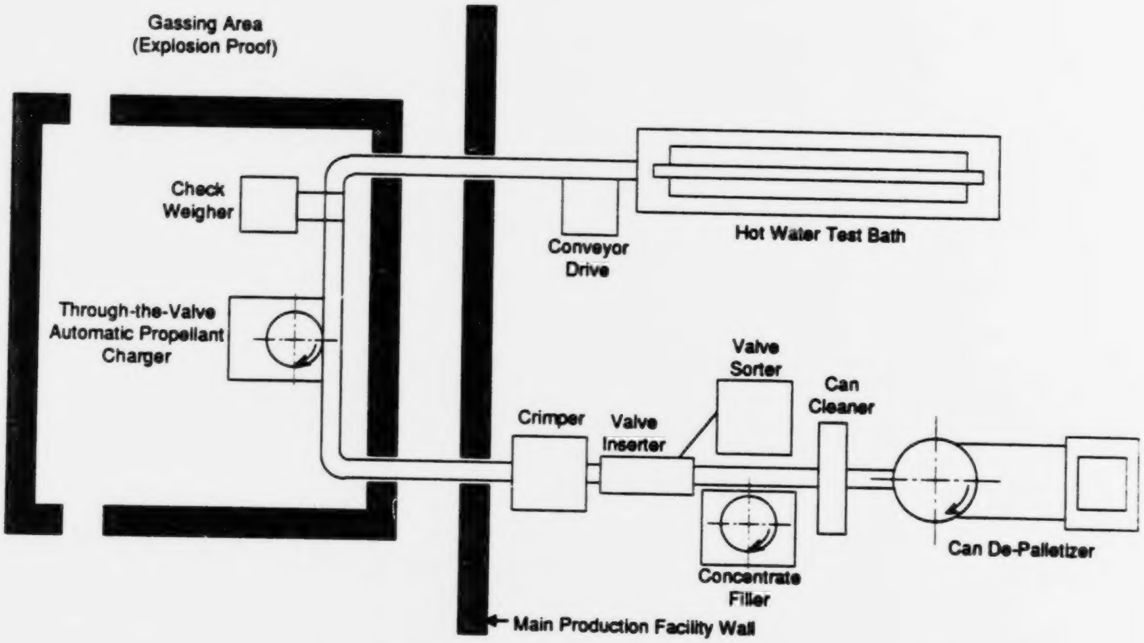
The equipment that must be modified to convert from CFC aerosols includes the propellant supply, the gassing area, and possibly the main production facility, depending on the location of the gassing area. Modifications to each of these areas are discussed below.

Propellant Storage

Automated filling lines typically use bulk storage of the hydrocarbon propellant. The size of the bulk tank installation depends on the following:


Gassing Area
(Explosion Proof)
Check Weigher
Under-the-Cap Rotary Filler/Crimper/Gasser Machine
Conveyor Drive
Hot Water Test Bath
Valve Sorter and Inserter
Vacuum Pump
Can Cleaner
Can De-Palletizer
Main Production Facility Wall

a)Rotary Under-the-Cap Filler/Crimper/Gasser


Gassing Area
(Explosion Proof)
Check Weigher
Conveyor Drive
Hot Water Test Bath
Through-the-Valve Automatic Propellant Charger
Valve Sorter
Can Cleaner
Crimper
Valve Inserter
Concentrate Filler
Can De-Palletizer
Main Production Facility Wall

b)Rotary Througn-the-Valve Gasser

Figure 4. Automated aerosol filling line.

TABLE 9. AUTOMATIC PRODUCTION FILLING LINE EQUIPMENT

Area	Item	Cost ($1000)	Modification
Base Product and Blending Areas	1. Base product raw material storage tanks and transfer pumps	0-20	Reformulation of base product may be required
	2. Scale/load cell for blending tank	0-15	Only if base product is reformulated
	3. Base product filling supply and transfer pump	0-5	If electric pump, switching to explosion-proof motor may be needed
Propellant Supply Area	1. Propellant storage tank	0-200	Cleaning, testing, and moving of tank may be needed
	2. Propellant booster pump to gasser	0-0.5	Converting to explosion-proof motor
	3. Pressure regulating valve, valve bypass	0-0.5	
Gassing Area	1. Product filler	0-1	Fittings and gaskets may need to be replaced depending on base product reformulation
	2. Propellant charger	0-1	Fittings and gaskets may need to be replaced depending on base product reformulation
	3. Crimper	0-1	Fittings and gaskets may need to be replaced depending on base product reformulation
	4. Vacuum pump	0-0.5	Converting to explosion-proof motor
Support Area	1. Packing table	0-0.25	Converting to explosion-proof motor
Optional	1. Hot tank (test bath)	0.5-10	Hood ventilation may be required
	2. Container dryer	0.25-0.5	Converting to explosion-proof motor

- Maximum daily propellant use;
- Number of different propellant grades required;
- Size of tanker delivery and ease of access;
- Time to process and receive tanker deliveries; and
- Location of tanks relative to adjacent buildings.

Installation of new tanks should follow the specific guidelines presented in NFPA 58 "Standard for the Storage and Handling of Liquified Petroleum Gases" (18). Additional specific and general guidelines for hydrocarbon propellant storage, use, and safety are discussed in NFPA 30B "Code for the Manufacture and Storage of Aerosol Products" (17), the British Aerosol Manufacturers' Association (BAMA) "A Guide to Safety in Aerosol Manufacture," and the Aerofill "Hydrocarbon Guide." The Aerofill document is reproduced in Appendix F. Ordering information for the NFPA codes and BAMA Guide appears in Appendix D.

One of the most important guidelines is intended to ensure that the distance between the tanks and charging pumps and the production and gassing areas meets specifications. Figure 5 shows the minimum recommended distances for two different storage tank sizes. NFPA 30B recommends a minimum distance of 8 meters (25 feet) from the nearest production facility for tanks under 7.6 m^3 (17). For tanks over 7.6 m^3, a distance of 15 meters is recommended (18). For propellant charging pumps, the minimum recommended distance is 7.6 meters from an adjacent wall, from all other walls and buildings, and from the nearest source of ignition, such as nonexplosion-proof electrical equipment or motor vehicles.

If existing fixed storage tanks are reused, they must be thoroughly cleaned (sandblasted) and hydrostatically tested at 2 times their maximum working pressure to ensure they can safely store the hydrocarbon propellant. The following example illustrates the evaluation of a fixed storage tank that could be converted from CFC to hydrocarbon propellant. Assume the tank was originally designed to contain a typical blend of 60 wt % CFC-12 and 40 wt % CFC-11. The vapor pressure of this blend would be 532 kPa gauge at 38°C (77.2 psig at 100°F). The American Society of Mechanical Engineers (ASME)

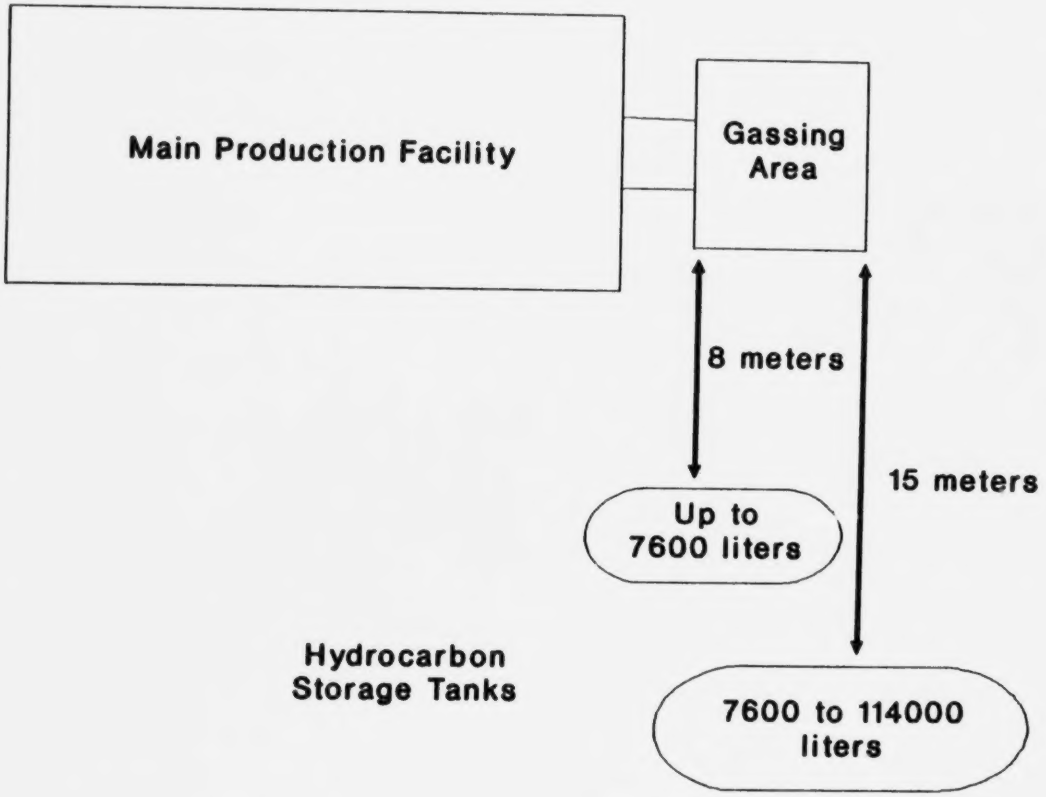

Main Production Facility
Gassing Area
8 meters
15 meters
Up to 7600 liters
Hydrocarbon Storage Tanks
7600 to 114000 liters

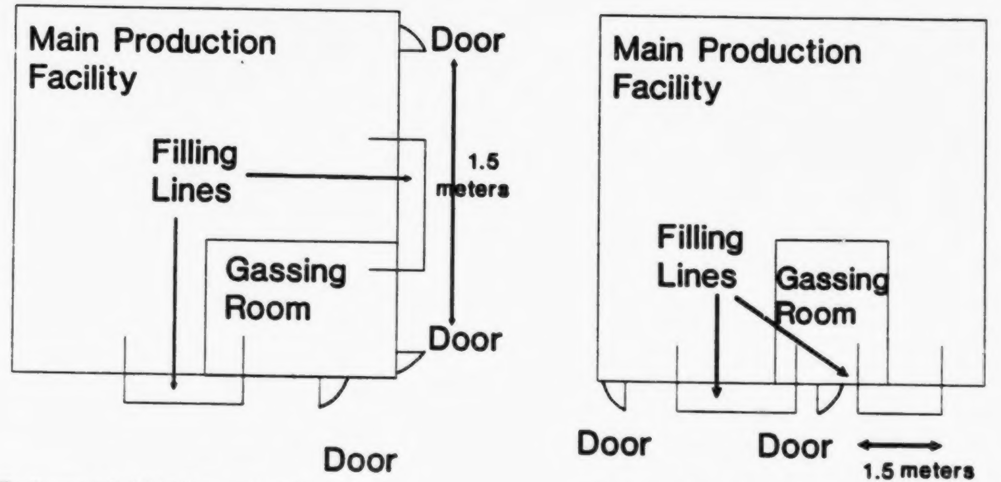
Figure 5. Recommended hydrocarbon storage tank distances.

code applies to any container over 454 L of liquid capacity and requires a minimum design pressure of 963 kPa. This tank could be approved for reuse with isobutane (501 kPa at 38°C) or n-butane (356 kPa at 37.8°C), but not with pure propane (1307 kPa at 38°C) or blends containing mostly propane. A typical hydrocarbon blend A-46 (containing ideally 15 wt % propane and 85 wt % isobutane) has a pressure of about 659-660 kPa at 38°C and would be only marginally acceptable in such a tank.

In addition, fixed storage tanks should be a minimum distance of 8 m (25 feet) from the gassing area; this may require moving existing tanks, lines, and pumps. Lines and pumps must be cleaned or replaced with material designed for flammable hydrocarbon liquids.

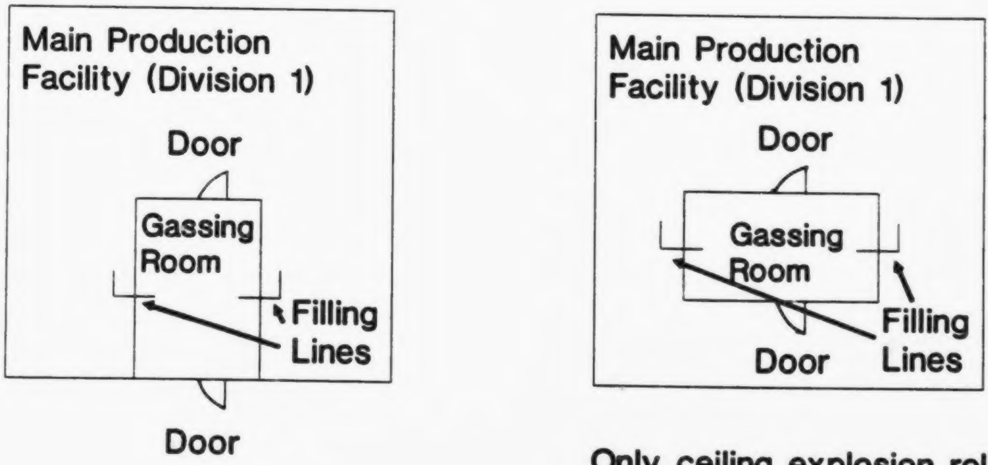
Gassing and Production Areas

In addition to the storage area, modifications may be needed for the gassing and production areas. The gassing room should be constructed outside the main production area, as shown in Figure 4. Figure 6 depicts four different interior gassing room locations (20). If the gassing area is located within a large area, as shown in the top two schematics of Figure 6, modifications can be made to the gassing room only. However, if the gassing room is contained within a small main production facility, as shown in the bottom two schematics of Figure 6, modifications to both the gassing room and the main production facility must be made. These changes would include increased ventilation, combustible gas detectors, electrical devices (motors, switches, and lights) enclosed in "explosion-proof" housings (as described earlier for Class I, Division 1, Group D atmospheres), and possibly an improved explosion suppression system. In addition, the walls and roof of the gassing room should be made blast proof. A gassing room located in the center of the main production facility (as shown in the lower right schematic of Figure 6) is not recommended because only ceiling explosion relief is possible in this design.


Main Production Facility
Door
Filling Lines
1.5 meters
Gassing Room
Door
Door
Main Production Facility
Filling Lines
Gassing Room
Door
Door
1.5 meters

External Walls of Gassing Room ≥ 50% of Wall Areas

External Walls of Gassing Room < 50% of Wall Areas


Main Production Facility (Division 1)
Door
Gassing Room
Filling Lines
Door
Main Production Facility (Division 1)
Door
Gassing Room
Filling Lines
Door

Only ceiling explosion relief is possible in this design.

Figure 6. Potential existing gassing room locations for automated filling lines.

For ventilation, all buildings should have an air flow rate of 0.3 m^3/min per m^2 of floor area provided (17). The gassing room may need more ventilation, which can be calculated as follows:

$$CM = \frac{(100\text{-}LEL)\ (V)\ (R)}{(DL)\ \ (LEL)}$$

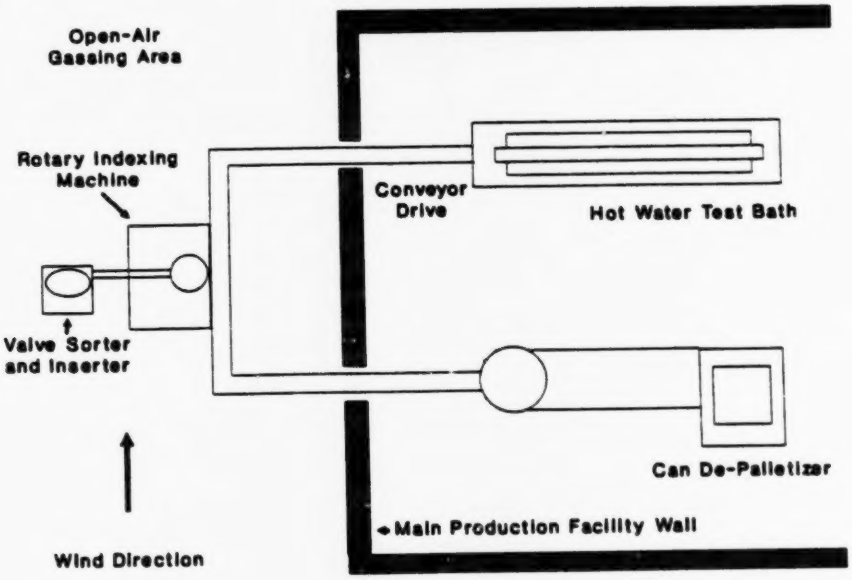
where CM is the required ventilation flow/rate (m^3 per minute) LEL is the lower explosive limit of the propellant (%), V is the vapor volume produced by 1 liter of liquid propellant (m^3), R is an estimate of the propellant lost during filling plus an additional 20% for occasional leaks (liters), and DL is the LEL design level (usually not more than 10% of the LEL). The estimated propellant lost during filling, R, can be calculated from:

$$R = (1\ \text{Liter}/1000\ cm^3) \times (\text{loss per can, } cm^3) \times (\text{cans per minute}) \times (1.2)$$

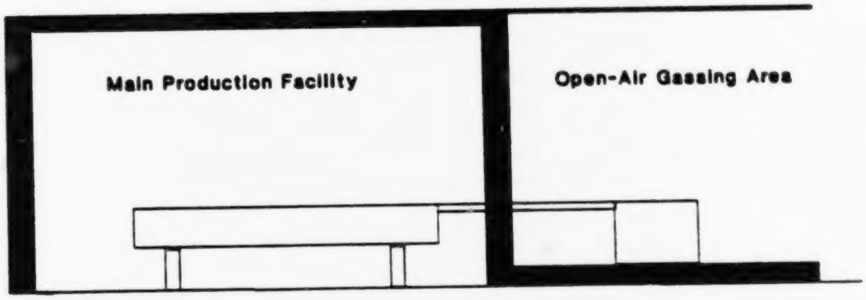
The typical loss per can for one filler line is 3.0 cm^3/can, and 4.0 cm^3/can for a two-filler line.

If a facility is not able to make the modifications suggested above, an open-air gassing room may be used. This type of gassing room, depicted in Figure 7, has been used successfully in Mexico for a number of years (19). The main feature of the open-air gas house is the use of natural ventilation to keep any escaped hydrocarbon vapors below flammable or explosive limits. The gassing apparatus is located outside of the main production facility, with a solid roof, and wire mesh walls on three sides, and a solid wall between the gassing area and the main production facility. Design considerations for an open-air gassing area include:

- Odor (is the hydrocarbon propellant stenched or unstenched);
- The LEL and relative flammability of the hydrocarbon propellant to be used;
- The typical wind speed and direction; and


Open-Air Gassing Area
Rotary Indexing Machine
Valve Sorter and Inserter
Wind Direction
Conveyor Drive
Hot Water Test Bath
Can De-Palletizer
Main Production Facility Wall

Open-Air Gassing Facility (Plan View)


Main Production Facility
Open-Air Gassing Area

Open-Air Gassing Facility (Side View)

Figure 7. Example of an open-air gassing area.

- Land availability and location of nearby buildings, parking lots, or electrical equipment.

This type of system has the advantage of not requiring mechanical ventilation (however, high-speed filling lines may need some additional ventilation with explosion-proof fans), or a blast-proof gassing room.

Table 9 contains the estimated cost range of suggested gassing and production area modifications. These costs, however, do not include additional ventilation that would be required, nor do they include blast-proofing the gas house. Conversion costs would be less for air-operated equipment than for electrically operated equipment. The costs of various explosion-proof electrical hardware are listed in Table 10. The approximate cost of a halon explosion suppression system for a large gassing area (3.5 m x 5.0 m) would be approximately $30,000 U.S. Dollars [based on three times (3x) the cost of a fire protection system from the Richardson Cost Manual (25) and conversations with system vendors.] System vendors caution that explosion suppression system costs cannot be estimated without site-specific details.

The Mexico Case Study, for example, estimated that the cost to convert an automated filling line (producing 8 million units per year) from CFCs to LPG was $566,000 for capital investment (machinery and filling lines) and $793,000 for auxiliary equipment (gas detectors, fire extinguishing systems, and alarms), resulting in a conversion cost of $1.36 million U.S. dollars. However, the estimated propellant savings from using less expensive hydrocarbons in place of CFCs would be $1.69 million U.S. per year. Therefore, the cost savings from converting to hydrocarbons would more than offset the initial capital investment (26).

MANUAL FILLING LINES

Small- to medium-sized aerosol-filling operations typically use a manual production line capable of producing 6,000 to 8,000 units per shift with two persons (limited to filling, gassing, and crimping only), which would equate to approximately 15 units per minute. On the basis of one 8-hour shift per

TABLE 10. PURCHASED EQUIPMENT COST FOR VARIOUS ELECTRICAL HARDWARE (GENERAL PURPOSE VS. EXPLOSION PROOF)

Item	Description		Rating	Cost
Junction Boxes	24"x24"x6-5/8"		NEMA 1 (Non-Hazardous)	$118
	30"x24"x8-5/8"		NEMA 1 (Non-Hazardous)	$146
	24"x24"x6"		NEMA 12 (Hazardous Environment)	$153
	30"x24"x8"		NEMA 12 (Hazardous Environment)	$180
Load Centers	100 Amp, 10 circuit		NEMA 1 (General Purpose)	$290
	225 Amp, 24 circuit		NEMA 1 (General Purpose)	$491
	125 Amp, 10 circuit		NEMA 3 (Hazardous Area)	$1,931
	225 Amp, 24 circuit		NEMA 3 (Hazardous Area)	$3,423
Circuit Breakers	15 Amp - 60 Amp		NEMA 1 (General Purpose)	$208
	15 Amp - 60 Amp		Explosion Proof	$482
Motor Starters	Non-Reversing, Size 0 240V @ 3HP, 480/600V @ 5HP		General Purpose	$139
	Non-Reversing Combination Size 0 240V @ 3HP, 480/600V @ 5HP		General Purpose	$452
	Non-Reversing, Size 0 240V @ 3HP, 480/600V @ 5HP		NEMA 7 or NEMA 9 (Explosion Proof)	$663
	Non-Reversing Combination Size 0 240V @ 3HP, 480/600V @ 5HP		NEMA 7 or NEMA 9 (Explosion Proof)	$942
Electric Motors (Single Phase) Rigid Mount	Horsepower	Enclosure		
	0.5	Protected Drip Proof		$232
		Totally Enclosed Fan Cooled		$256
		Explosion Proof	Class I, Group D	$416
	1.0	Protected Drip Proof		$456
		Totally Enclosed Fan Cooled		$480
		Explosion Proof	Class I, Group D	$1,000
	2.0	Protected Drip Proof		$488
		Totally Enclosed Fan Cooled		$508
		Explosion Proof	Class I, Group D	$684
(Polyphase) NEMA C End Mount	1.5	Protected Drip Proof		$362
		Totally Enclosed Fan Cooled		$407
		Explosion Proof	Class I, Group D	$667

Source: Reference 25.

day and a 5-day work week, such a plant could conceivably produce nearly 2 million units per year. Other operations, such as labeling containers with paper labels or packing, would either slow the rate or require additional labor.

A manual aerosol-filling line is illustrated in Figure 8. The equipment is typically air operated and manually actuated through a lever or button. Each container must be transferred manually from one step to the next. Table 11 lists the equipment and its estimated cost in U.S. dollars (1990 basis) for a manual filling line. Modifications to the hydrocarbon storage area and the gassing areas for the smallest manual filling operations are discussed below. Cold filling is not appropriate with hydrocarbon propellants and should be replaced by pressure filling. A single-station pressure filling machine may cost up to $30,000.

Hydrocarbon Storage Area

As depicted in Figure 9, the hydrocarbon storage used for the small, manual filling lines are typically several 53-kg cylinders manifolded together or a 385-kg container. Cylinders not in use should be stored in the open air or in well-ventilated areas. No more than six cylinders should be stored together with a minimum distance of 3 meters between the storage and a boundary, building, or fixed ignition source (such as pumps, electrical motors, or vehicles). All cylinders should be stored upright with protective valve caps in place and securely chained. Full and empty cylinders should be identified and segregated.

In-use cylinders should be manifolded together using changeover valves and nonreturn valves. As with the in-storage cylinders, in-use cylinders should be upright and securely chained. Piping from the cylinder or manifold should be done with hydrocarbon-compatible materials. The piping route to the gassing area should avoid steam pipes and other sources of ignition or heat. Individual piping should be used for each grade of hydrocarbon propellant used.

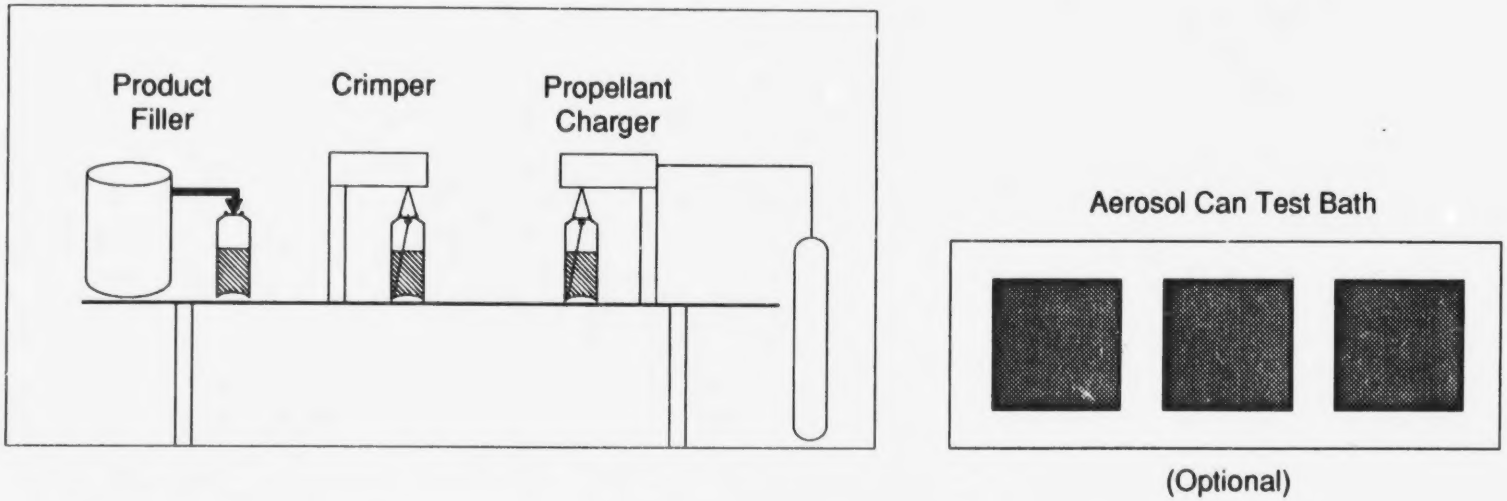
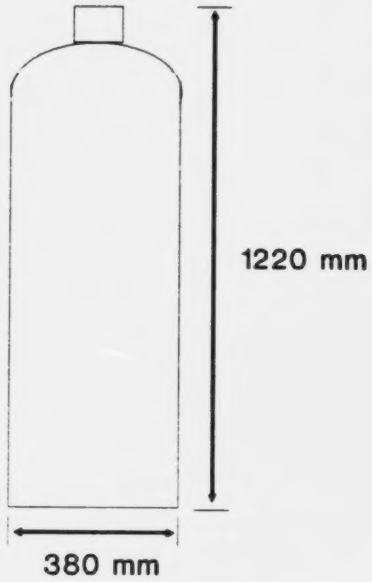

Product
Filler
Crimper
Propellant
Charger
Aerosol Can Test Bath
(Optional)

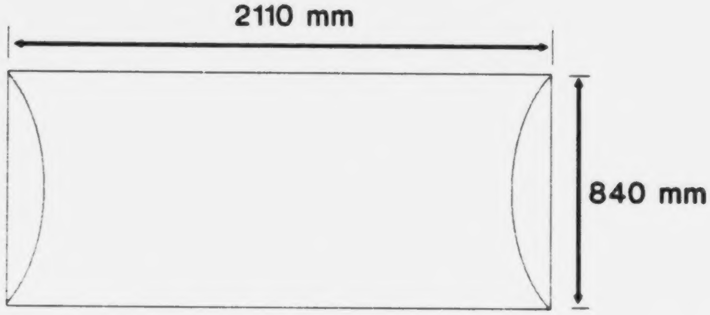
Figure 8. Example of a manual filling line.

TABLE 11. SMALL MANUAL PRODUCTION FILLING LINE EQUIPMENT LIST

Area	Item	Cost ($)	Modification
Base Product and Blending Areas	1. Base product transfer pump	0	Manual pump assumed for base product transfer
Propellant Supply Area	1. Propellent cylinder storage area	$1,500	Fencing, chain, cover for outside cylinder storage
	2. Propellant booster pump to gasser	$500	Conversion to explosion-proof motor
Crimper	1. Addition of vacuum pump	$1,700	Explosion-proof vacuum pump (cold filling not used)
Gasser	1. Propellant charger	$700	Fittings, gaskets, valves replaced with propellant compatible materials
	2. Fume hood	$3,000	Fume hood (explosion-proof with rear exhaust duct)
Test Bath	1. Fume hood	$2,600	Fume hood (explosion-proof with rear exhaust duct)
	Subtotal Capital	$10,000	
	Installation Costs (20%)	$2,000	
	Total Capital for Modifications	$12,000	


1220 mm
380 mm

Hydrocarbon Cylinder
Contents 53 Kg


2110 mm
840 mm

Hydrocarbon Container
Contents 385 Kg

Figure 9. Hydrocarbon storage for manual filling lines.

Piping should be of seamless carbon steel as specified in ASTM Specification A-53 Grade B [equivalent to American National Standards Institute (ANSI) Designation B36.1], with a minimum tensile strength of 414 MPa (60,000 psi). The pipe should be a minimum of Schedule 80 if threaded fittings are used or if the pipe is to be back-welded or buried. No less than Schedule 40 pipe should be used if the fittings are to be welded or welded and flanged (20). Gaskets and packing must also be compatible with hydrocarbons. Examples of some materials are tetrafluoroethylene (TFE), Kel-F, and metal-encapsulated asbestos substitutes. All applicable codes for piping and gasket/sealing materials should be consulted before commissioning any new hydrocarbon piping system.

If existing CFC cylinders are reused, they must be thoroughly cleaned (sandblasted) and hydrostatically tested at 2 times their maximum working pressure to ensure that they can safely store the hydrocarbon propellant. In addition, lines and pumps must be cleaned or replaced with material designed for flammable hydrocarbon liquids.

Additional discussions and more specific guidelines for storing and using hydrocarbon propellants appear in Appendix F and in References 17 through 20.

Gassing Area

In addition to the propellant supply, equipment modifications for manual lines also must be made to the gassing area. Many small filling operations are located in crowded urban areas, and the use of an open-air gassing area would not be possible. One way to significantly reduce the hazards associated with hydrocarbon propellants would be to locate the gassing and crimping operations within a laboratory fume hood. These types of hoods have been successfully used for laboratory-scale, manual filling operations that closely correspond to cottage-size production facilities.

Although fume hoods can vary in size, they are typically 76 cm deep, 100 cm high, and from 122 to 240 cm wide. A fume hood for use with hydrocarbon propellants has a vertical sash, an air face velocity of at least 30 to 45 meters per minute, and air exhaust vents located at the bottom rear of the hood. Having the air exhaust at the bottom rear of the hood is very important, since hydrocarbon propellants are more dense than air and will collect at the bottom of the hood. Table 12 gives additional minimum air flow requirements for different hood sizes.

The exhaust from the fume hood should be connected to a flue or pipe duct that uses an explosion-proof fan motor. The end of the duct or piping should exit directly through the roof of a one-story building or to an adjacent outside wall if the filling room is located in a multi-story building. The location of any ignition sources that may be near the exhaust duct should be considered. The fume hood, fan-motor, and any equipment used within the fume hood (such as lighting) should be Class I, Division 1, Group D explosion-proof equipment. Table 10 shows the costs for various explosion proof equipment. The costs for the laboratory hood are for a 122-cm-(48-in.) wide benchtop; a walk-in hood of the same width would be approximately twice as expensive. Explosion suppression system vendors should be consulted for details on installing these systems in laboratory hoods (see Appendix A).

Table 11 presents the costs for converting a manual filling line. This size of filling line is assumed to produce 0.5 million units per year. The total capital cost for conversion to hydrocarbon propellants is estimated to be at least $12,000 U.S. Modifications to equipment would include purchase of explosion-proof motors, starters, and solenoid valves; installation of explosion-proof fume hoods for the gassing equipment and test baths; and construction of a covered, fenced hydrocarbon storage area. This initial capital investment would be more than recovered by the material cost savings of using hydrocarbon propellants in place of CFC propellants. This cost savings would be nearly $67,700 per year. The costs for CFC propellant would be $75,000 per year (assuming a 340-gram aerosol can, 30% by weight of CFC propellant, and a CFC cost of $2.21 U.S. per kg), compared to a hydrocarbon propellant cost of $7,300 U.S. per year (using isobutane at $0.44 U.S. per kg).

TABLE 12. FUME HOOD MINIMUM AIR FLOW REQUIREMENTS

Hood Width (meters)	Minimum Air Flow (m^3/minute) for Face Velocities of 30 m/s	46 m/s
1.2	23	34
1.5	28	42
1.8	34	51
2.4	45	68

Source: Reference (27).

SECTION 5

PRODUCT STORAGE FOR DISTRIBUTION AND SALE

This manual not only provides manufacturers of aerosol products with information that will enable them to convert from CFC to hydrocarbon propellants, but also contains information on proper product storage, including warehouse, backstock, and sales display storage. Since hydrocarbon propellants are flammable (containing butane, propane, or a mixture of these two, and, less frequently, pentane or ethane), producers, distributors, and end users must take extra care to handle them safely. This section discusses issues relating to the storage of flammable products such as 1) the classification of aerosol products into three levels according to their perceived flammability hazard, 2) the 1990 NFPA 30B Code for the Manufacture and Storage of Aerosol Products, and 3) what the Code says about the storage and display of the three levels of hydrocarbon aerosols.

In the United States, four organizations develop the fire and building codes: The National Fire Protection Association (NFPA), the International Conference of Building Officials (ICBO) with the Western Fire Chiefs Association, the Southern Standard Building Code International (SSBCI), and the Building Officials and Code Administrators (BOCA). The last three are regional building and fire code organizations that generally produce codes that closely follow the criteria set by the NFPA. Codes developed by the regional organizations generally become adopted into state, county, and city laws and regulations.

CLASSIFICATION OF AEROSOL PRODUCTS

The NFPA 30B Code for the Manufacture and Storage of Aerosol Products classifies these products in three categories. Table 13 shows how aerosol products are classified according to their percentage of flammable base material and flammable propellant. Materials that mix with water, such as ethanol, isopropanol, propylene glycol, glycerin, sorbitol, acetone, methyl

TABLE 13. CLASSIFICATION OF AEROSOL PRODUCTS (17)

If Percentage of Flammable Material in Base Product Is:	And Percentage of Flammable Propellant Is:	Then Level Is:
≤25%	0%[a]	1
≤25%	<50%	1
≤25%	≥50% but <80%	2
<85% and water-miscible	0%[a]	1
>25% and water-miscible	<50%	2
>25% and water-miscible	≥50%	3
>25% but ≤55% and water-immiscible	0%	2
>25% but ≤55% and water-immiscible	<50%	2
>25% but ≤55% and water-immiscible	≥50%	3
>55% and water-immiscible	0% to 100%	3
any %	≥80%	3

[a] i.e., propellant is nonflammable.

NOTE 1: The base product is defined as the contents, excluding the propellant. A base product component is considered flammable if its flash point is below 260°C (500°F). The percentage of flammable material in the base product is calculated as follows:

$$\text{\% Flammable Material} = \frac{\text{Weight of Flammable Base Components}}{(\text{Wt. of Contents} - \text{Wt. of Propellant})} \times 100$$

NOTE 2: The percentage of flammable propellant is its proportion of the total contents, by weight. Any nonflammable portion of a propellent blend is not included in the calculation. The percentage is calculated as follows:

$$\text{\% Flammable Material} = \frac{\text{Weight of Flammable Base Components}}{\text{Weight of Contents}} \times 100$$

ethyl ketone, methyl acetate, and most surfactants, for example, would dissolve in the water from sprinklers and fire hoses during a fire and be rendered nonflammable. Water immiscible materials, on the other hand, such as toluene and aliphatic petroleum distillates, would not dissolve and could spread as a burning top layer as water was directed at a fire.

Figure 10 is a "decision tree" showing how to determine the level number of an aerosol product (17). In Level 1 products, the base product contains up to 25% by weight of materials with flash points of 260°C (500°F) or less. In Level 2 products, the base product contains either 1) more than 25% by weight of water miscible materials with flash points of 260°C (500°F) or less, or 2) more than 25% but less than 55% of water immiscible materials with flash points of 260°C (500°F) or less. In Level 3 products, the base product contains more than 55% of water miscible materials with flash points of 260°C (500°F) or less, or the flammable propellant equals or exceeds 80% of the net container weight.

NFPA 30B: CODE FOR THE MANUFACTURE AND STORAGE OF AEROSOL PRODUCTS (1990)

In the late 1970s and early 1980s, actual fire incidents and full-scale fire testing made it apparent that flammable aerosol products presented a severe fire challenge. In response, the aerosol industry initiated further full-scale fire testing, and NFPA's Technical Committee on Aerosol Products began working on fire protection guidance for both manufacturing and storage facilities. NFPA 30B became effective on August 17, 1990. This section summarizes Chapters 4 and 5 of Code 30B, which describe NFPA's basic requirements for storing and displaying aerosol products.

Storage in Warehouses and Storage Areas

In the U.S., all cartons of aerosol products produced after January 1, 1992 must show the classification of the aerosol products within somewhere on the carton. Level 1 aerosol products are equivalent to a Class III commodity, i.e., to paper, cardboard, and wood products (28). These "water-based"

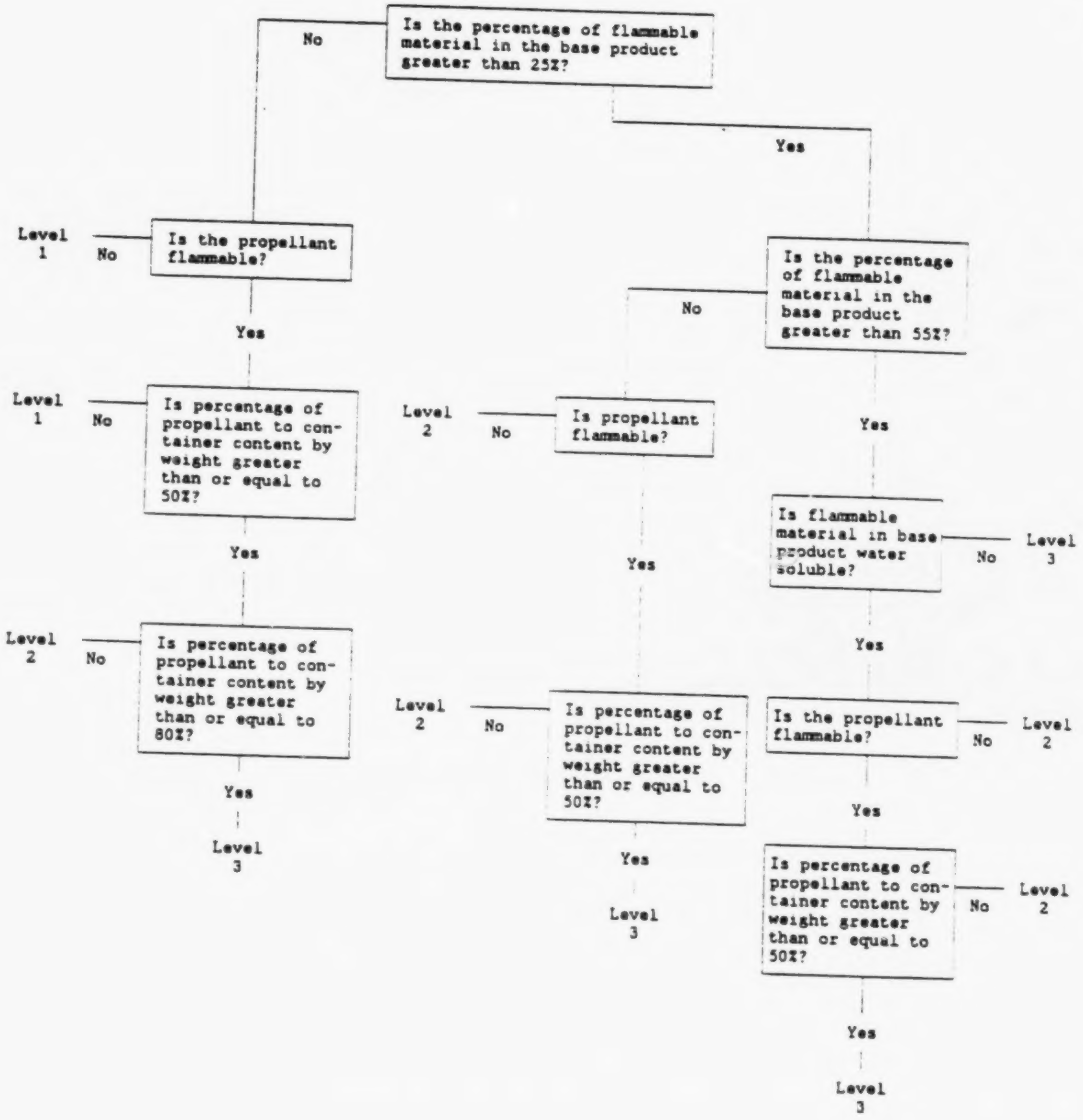

Is the percentage of flammable material in the base product greater than 25%?
No
Yes
Level 1
No
Is the propellant flammable?
Yes
Level 1
No
Is percentage of propellant to container content by weight greater than or equal to 50%?
Yes
Level 2
No
Is percentage of propellant to container content by weight greater than or equal to 80%?
Yes
Level 3
Is the percentage of flammable material in the base product greater than 55%?
No
Level 2
No
Is propellant flammable?
Yes
Level 2
No
Is percentage of propellant to container content by weight greater than or equal to 50%?
Yes
Level 3
Yes
Is flammable material in base product water soluble?
No
Level 3
Yes
Is the propellant flammable?
No
Level 2
Yes
Is percentage of propellant to container content by weight greater than or equal to 50%?
No
Level 2
Yes
Level 3

Figure 10. "Decision tree" for determining aerosol product level number (Adapted from Ref. 17).

aerosol products, examples of which appear in Table 14, do not require special fire protection measures. Level 2 aerosol products in containers whose net weight of flammable contents is less than 1 ounce may be stored as Group A plastics, as defined by NFPA 231. Tables 15 and 16 list examples of Level 2 and Level 3 aerosol products, respectively.

Tables 17 through 22 show how Level 2 and Level 3 aerosols being stored on pallets, in solid piles, or on racks should be arranged and protected from fire. The tables give details about sprinkler spacing, the necessary duration of sprinkler performance, and maximum ceiling and pile heights when ordinary or Early Suppression Fast Response (ESFR) sprinklers are used. In general, the pile height can increase when ESFR or large drop sprinklers are used; sprinkler duration varies from one to two hours.

Up to 454 kg (1000 lbs) net weight of Level 2 and up to 227 kg (500 lbs) of Level 3 aerosol products [or up to 454 kg (1000 lbs) of Level 2 and Level 3 aerosols combined] can be stored in places other than warehouses, i.e., in business, educational, industrial, and institutional environments.

Up to 5450 kg (12,000 lbs) of combined Level 2 and Level 3 aerosol products can be stored in general purpose warehouses in solid piles or on pallets if: 1) the sprinkler system over the aerosol area and 6 m (20 ft) beyond conforms to the standards shown in Tables 17 and 18; and 2) any flammable and combustible liquids stored in the same warehouse are separated from the aerosol products by at least 8 m (25 ft).

According to NFPA Code 30B, up to 10,900 kg (24,000 lbs) of Level 2 and Level 3 aerosol products combined may be stored in racks in a general purpose warehouse protected by an automatic sprinkler system if: 1) the sprinkler system for the aerosol storage area and 6 m (20 ft) beyond meets the standards shown in Tables 19 through 22; and 2) the aerosol products are separated from any flammable and combustible liquids by at least 8 m (25 ft).

TABLE 14. EXAMPLES OF LEVEL 1 AEROSOL PRODUCTS (29)

Air Fresheners - Water-based
Insecticides - Water-based
Herbicides - Water-based
Shave Creams
Starches & Fabric Finishes
Many Furniture Polishes - Water-based
Kitchen & Bathroom Cleaners
Oven Cleaners (both caustic and noncaustic formulas)
Mousse Products
Engine Cleaners - Water-based
Whitewall Tire Cleaners
Fabric Dewrinklers
Anti-static Sprays - Water-based
Some Cookware Release Sprays - Water-based
Rug & Upholstery Shampoos
Whipped Creams
Pet Shampoos & Conditioners

TABLE 15. EXAMPLES OF LEVEL 2 AEROSOL PRODUCTS (30)

A. Alcoholic or Hydro-alcoholic types
  - Hair Sprays--Anhydrous
  - Hair Sprays--To 9% water, in solution
  - Hair Sprays--Dimethyl Ether type--to 20% water in solution
  - Hair Sprays--Two-phase type--to 30% water
  - Disinfectant/deodorants--CO_2 type
  - Disinfectant/deodorants--Hydrocarbon type
  - Personal Deodorants
  - Air Fresheners--Anhydrous
  - Air Fresheners--To 6% water in solution
  - Perfumes and Colognes
  - Windshield De-icers
  - Some Breath Fresheners
  - Deo-colognes
  - Certain Mousse Products (Rare)
  - De-wrinklers--for Fabrics
  - Certain Topical Medicinals

b. Petroleum Distillate Emulsions
  - Furniture Polishes
  - Furniture Cleaners
  - Laundry Prewash Spot Removers
  - Engine Cleaners (Exterior)--Water-based
  - Certain Paints and Coatings--Water-based
  - Certain Insecticides--Water-based
  - Certain Herbicides--Water-based
  - Certain Leather or Vinyl Dressings

c. Alcohol and Water Immiscible Oil Types
  - Ethanol-based Insect Repellents--CO_2 or Hydrocarbon
  - Isopropanol-based Insect Repellents--CO_2
  - Certain Lubricants
  - Certain Mousse products, e.g., Mineral Oil Types
  - Certain Hair Glossing Sprays

d. Miscellaneous
  - Diethyl-Ether Engine Starting Fluid--CO_2 or CO_2/A-60 Types
  - Diacetone Alcohol Carburetor Cleaners--CO_2 Types
  - Methanol Gel for Pot, Urn, or Food Tray Warmer Refills
  - Methyl Acetate-based Graffiti Removers

TABLE 16. EXAMPLES OF LEVEL 3 AEROSOL PRODUCTS (31)

Most Spray Paints
Most Automotive Products (such as choke and carburetor products)
Most Aerosol Antiperspirants
Some Dry Powder Drug Products
Some Pesticides (such as some total release insect foggers and wasp/hornet sprays)
Some Lubricants
Some Solvent-based Herbicides

TABLE 17. ARRANGEMENT AND PROTECTION OF PALLETIZED AND SOLID-PILE LEVEL 2 AEROSOL STORAGE[a] (17)

Max. Ceiling Ht (m)	9.1	9.1	7.6	7.6
Maximum Pile Ht (m)	1.5	4.6	5.5	6.1
Sprinkler	1.27 cm.	ESFR	Large drop 1.63 cm	ESFR
Temp. Rating[b]	High	Ordinary	Ordinary	Ordinary
Sprinkler Spacing (m^2)	9.3 max.	7.4-9.3	7.4-9.3	7.4-9.3
Sprinkler Demand	3.6 $L/min/m^2$ over 232 m^2	12 sprinklers at 446 kPa	15 sprinklers at 446 kPa	12 sprinklers at 446 kPa
Duration (hr)	2	1	2	1

[a] All fire tests on which this table is based were conducted with standard spray, large drop, or ESFR sprinklers. This does not include large drop sprinklers equipped with quick response links. The Response Time Index (RTI) of standard spray and large drop sprinklers shall not be less than 100 $(meter/sec)^{1/2}$ [181 $(ft/sec)^{1/2}$].

[b] When use of higher temperature-rated sprinklers is necessary, such as near unit heaters, refer to NFPA 13, Standard for the Installation of Sprinkler Systems.

TABLE 18. ARRANGEMENT AND PROTECTION OF PALLETIZED AND SOLID-PILE LEVEL 3 AEROSOL STORAGE[a] (17)

Max. Ceiling Ht (m)	9.1	9.1	7.6	7.6
Maximum Pile Ht (m)	1.5	4.6	4.6	3
Sprinkler	1.27 cm	ESFR	ESFR	Large drop 1.63 cm
Temp. Rating[b]	High	Ordinary	Ordinary	Ordinary
Sprinkler Spacing (m^2)	9.3 max.	7.4-9.3	7.4-9.3	7.4-9.3
Sprinkler Demand	7.2 L/minute/m^2 over 232 m^2	12 sprinklers at 618 kPa	12 sprinklers at 446 kPa	15 sprinklers at 618 kPa
Duration (hr)	2	1	1	2

[a] All fire tests on which this table is based were conducted with standard spray, large drop, or ESFR sprinklers. This does not include large drop sprinklers equipped with quick response links. The Response Time Index (RTI) of standard spray and large drop sprinklers shall not be less than 100 $(\text{meter/sec})^{1/2}$ [181 $(\text{ft/sec})^{1/2}$].

[b] When use of higher temperature-rated sprinklers is necessary, such as near unit heaters, refer to NFPA 13, Standard for the Installation of Sprinkler Systems.

TABLE 19. ESFR ARRANGEMENT AND PROTECTION OF LEVEL 2 RACK STORAGE[a] (17)

Max. Ceiling Ht (m)	9.1	7.6
Maximum Storage Ht (m)	4.6	6.1
Temp. Rating[b]	Ordinary	Ordinary
Sprinkler Spacing (m^2)	7.4-9.3	7.4-9.3
Sprinkler Demand	12 sprinklers at 446 kPa	12 sprinklers at 446 kPa
Hose Stream Demand (L/minute)	946	946
Duration (hr)	1	1

[a] Single and double row racks only.

[b] When use of higher temperature-rated sprinklers is necessary, such as near unit heaters, refer to NFPA 13, Standard for Installation of Sprinkler Systems.

TABLE 20. ESFR ARRANGEMENT AND PROTECTION OF LEVEL 3 RACK STORAGE[a] (17)

Max. Ceiling Ht (m)	9.1	7.6
Maximum Storage Ht (m)	4.6	4.6
Temp. Rating[b]	Ordinary	Ordinary
Sprinkler Spacing (m^2)	7.4-9.3	7.4-9.3
Sprinkler Demand	12 sprinklers at 618 kPa	12 sprinklers at 446 kPa
Hose Stream Demand (L/minute)	946	946
Duration (hr)	1	1

[a] Single and double row racks only.

[b] When use of higher temperature-rated sprinklers is necessary, such as near unit heaters, refer to NFPA 13, Standard for Installation of Sprinkler Systems.

TABLE 21. PROTECTION OF RACK STORAGE OF LEVEL 2 AEROSOLS WITH STANDARD SPRAY SPRINKLERS (17)

Ceiling Sprinkler Arrangement	In-Rack Sprinkler Arrangement	Clearances: Storage to Sprinklers	Ceiling Demand	In-Rack Sprinkler Demand	Duration: Sprinklers and Hose Stream
141°C (286°F) rated; 9.3 m^2 max. spacing 1.27 cm orifice	≤74°C (165°F) rated; sprinklers 2.4 m apart max. One line at each tier except top. Locate in longitudinal flue spaces double-row racks.	4.6 m Need barrier with sprinklers beneath if clearance exceeds 15 ft. (See note.)	3.6 L/minute/m^2 over 232 m^2	30 psi per sprinkler minimum. Based on operation of hydraulically most remote: (1) 8 sprinklers if one level. (2) 6 sprinklers each of 2 levels if only 2 levels. (3) 6 sprinklers on top 3 levels if 3 or more levels.	2 hr

NOTE: Provide approved rack storage sprinklers with built-in water shields. Locate longitudinal flue in-rack sprinklers at least 0.6 m (2 ft) from rack uprights. Provide at least 150 mm (6 in.) between sprinkler deflectors and top of storage in tier.

TABLE 22. PROTECTION OF RACK STORAGE OF LEVEL 3 AEROSOLS WITH STANDARD SPRAY SPRINKLERS (17)

Ceiling Sprinkler Arrangement	In-Rack Sprinkler Arrangement	Clearances: Storage to Sprinklers	Ceiling Demand	In-Rack Sprinkler Demand	Duration: Sprinklers and Hose Stream
141°C (286°F) rated 17/32 in. orifice 9.3 m^2 max. spacing.	≤74°C (165°F) rated; sprinklers 2.4 m apart max. Install in longitudinal flue and on face of each tier.	1.5 m or less	3.6 L/minute/m^2 over 232 m^2	113 L/minute per sprinkler minimum. Based on operation of hydraulically most remote: (1) 8 sprinklers if one level. (2) 6 sprinklers each of 2 levels if only 2 levels. (3) 6 sprinklers on top 3 levels if 3 or more levels.	2 hr
		More than 1.5 m to 4.6 m	7.2 L/minute/m^2 over 139 m^2 to 232 m^2 Interpolate for clearances between 1.5 m and 4.6 m	113 L/minute per sprinkler minimum. Based on operation of hydraulically most remote: (1) 8 sprinklers if one level. (2) 6 sprinklers each of 2 levels if only 2 levels. (3) 6 sprinklers on top 3 levels if 3 or more levels.	2 hr
		More than 4.6 m	7.2 L/minute/m^2 over 232 m^2 plus a barrier above top tier with face sprinklers below.	113 L/minute per sprinkler minimum. Based on operation of hydraulically most remote: (1) 8 sprinklers if one level. (2) 6 sprinklers each of 2 levels if only 2 levels. (3) 6 sprinklers on top 3 levels if 3 or more levels.	2 hr

(Continued)

TABLE 22. (Continued)

Ceiling Sprinkler Arrangement	In-Rack Sprinkler Arrangement	Clearances: Storage to Sprinklers	Ceiling Demand	In-Rack Sprinkler Demand	Duration: Sprinklers and Hose Stream
	≤76°C (165°F) rated; sprinklers 2.4 m (8 ft) apart max. One line at each except top. Locate in longitudinal flue.	Up to 4.6 m	7.2 L/minute over 232 m^2	113 L/minute per sprinkler minimum. Based on operation of hydraulically most remote: (1) 8 sprinklers if one level. (2) 6 sprinklers each of 2 levels if only 2 levels. (3) 6 sprinklers on top 3 levels if 3 or more levels.	2 hr
		More than 4.6 m	7.2 L/minute over 232 m^2 plus a barrier above top tier with face sprinklers below	113 L/minute per sprinkler minimum. Based on operation of hydraulically most remote: (1) 8 sprinklers if one level. (2) 6 sprinklers each of 2 levels if only 2 levels. (3) 6 sprinklers on top 3 levels if 3 or more levels.	2 hr

NOTE: Provide approved rack storage sprinklers with built-in water shields. Locate longitudinal flue in-rack sprinklers at least 0.6 m (2 ft) from rack uprights. Provide at least 150 mm (6 in.) between sprinkler deflectors and top of storage in tier.

Segregated storage of Level 2 and Level 3 aerosol products is permitted under the Code if the warehouse is protected throughout by an automatic sprinkler system designed according to NFPA 231. To prevent aerosol products from rocketing and spreading a fire, Level 2 and Level 3 products must be segregated from the rest of the warehouse by interior walls, chain link fencing, or a separation area. The chain link fencing must extend from the floor to the roof deck or ceiling.

The Code permits quantities of Level 2 and Level 3 aerosol products in excess of the amounts discussed above only in warehouses dedicated to the storage of aerosol products, and fire protection must be for the highest level of aerosol product present. The Code leaves to the jurisdiction of individual area and regions whether aerosol warehouses may be unprotected by sprinkler systems when located at least 30 m (100 ft) from exposed buildings or adjoining property, if those buildings or property are themselves protected. Otherwise, the minimum distance is 60 m (200 ft). Other hazardous materials, such as flammable liquids, may also be stored in unlimited quantities within such a building.

Level 2 and Level 3 aerosol products stored in a warehouse meant for storing liquids must be within a segregated area separated from the rest of the warehouse by either interior walls or chain link fencing, and the area must be protected by a sprinkler system such as described in Tables 17 through 22. Fire doors or gates leading into the segregated storage area should be self-closing or activated by water flow or by the fire detection system to close automatically.

Up to 454 kg (1000 lbs) of Level 2 or 227 kg (500 lbs) of Level 3 aerosol products, or 1000 lbs of combined Level 2 and Level 3 products, may be stored separately inside flammable liquid storage rooms of 47 m^2 (500 ft^2) or less if the rooms meet the NFPA 30 Flammable and Combustible Liquids Code. If the room is larger than 47 m^2 (500 ft^2) up to 1135 kg (2500 lbs) of Level 2 or 454 kg (1000 lbs) of Level 3 aerosol products, or 1135 kg of Level 2 and Level 3 combined, may be stored in this way. If the room is protected by sprinkler systems such as those described in Tables 17 through 22, up to 2270 kg (5000 lbs) of Level 2 and Level 3 aerosol products may be stored.

Level 2 and Level 3 aerosol products stored outdoors should be located as far as possible from buildings and other important structures. At least 15 m (50 ft) separation should be maintained between these aerosol products and other combustible yard storage. Temporary storage trailers must also be located at least 15 m from other unprotected outdoor storage or from the property line.

Sales Display Areas

The display of Level 1 aerosol products is not regulated by NFPA 30B. Level 2 and Level 3 products, however, should be removed from combustible cartons in sales display areas unless: 1) the area is protected by sprinkler systems such as those described in Tables 17 through 22; or 2) the cartons are display-cut--i.e., only the bottom 50 mm (2 inches) of the side panels remains. In addition, the quantities displayed in unprotected areas should not exceed the following:

Floor	Maximum Net Weight Per Floor, kg (lb)
Basement	Not Permitted
Ground	1135 (2500)
Upper	227 (500)

The aerosol products should be stacked not more than 1.8 m (6 ft) high from the base to the top of the display unless they are placed on fixed shelving.

Backstock Storage Area

When backstock areas are separated from the sales display areas by construction that has at least a one-hour fire resistance, Level 2 and Level 3 aerosol products must be stored as described in the previous subsection entitled Storage in Warehouses and Storage Areas. If backstock areas are not separated from the sales display areas by one-hour fire resistant construction, Level 2 and Level 3 aerosol products must be counted in the total allowed in a sales display area, as described in the previous subsection entitled Sales Display Areas. Additional quantities of Level 2 and Level 3 aerosol products, however, may be stored in backstock areas in flammable liquids storage cabinets or flammable liquids storage rooms.

SECTION 6

PRODUCT REFORMULATION

FORMULATIONS

Aerosol products can be divided into the categories used in the U.S. Chemical Specialties Manufacturers' Association (CSMA) Pressurized Products Survey (32):

1. Insect Sprays
    - A. Space Insecticides (flying insect spray, house and garden spray)
    - B. Residual Insecticides (insect repellents, moth proofers, ant and roach killer)

2. Paints and Finishes
    - A. Paints, Primers, and Varnishes
    - B. Other related products (strippers, graffiti removers, decorative "snow")

3. Household Products
    - A. Room Deodorants and Disinfectants
    - B. Cleaners (glass, oven, rug, fabric, wall, and tile)
    - C. Laundry Products (starch, fabric finish, prewash)
    - D. Waxes and Polishes
    - E. Other Household Products (shoe polishes, dyes, leather dressings, anti-static sprays)

4. Personal Products
    - A. Shaving Lather
    - B. Hair Spray
    - C. All Other Hair Products (mousse, lusterizers)

   - D. Medicinals and Pharmaceuticals (vaporizers, fungicides, antiseptics, contraceptives)
   - E. Colognes, Perfumes, and After Shave
   - F. Personal Deodorants, Antiperspirants, Powders and Deodorant Colognes
   - G. Other Personal Products (suntan preparations, lotions, breath fresheners, depilatories)

5. Animal Products

   (Includes veterinary and pet products such as shampoos, insecticides, repellents)

6. Automotive, Industrial & Miscellaneous Household Lubes
   - A. Refrigerants
   - B. Windshield and Lock Spray De-icers
   - C. Cleaners (automotive upholstery, leather or vinyl dressing, tire cleaners)
   - D. Engine Degreasers
   - E. Lubricants and Silicones (penetrating oils, demoisturizers, rust proofing, mold releases)
   - F. Spray Undercoating
   - G. Tire Inflators and Sealants
   - H. Carburetor and Choke Cleaners
   - I. Brake Cleaner
   - J. Engine Starting Fluid
   - K. Other Automotive and Industrial Products (adhesives)

7. Food Products

   (Includes all types such as pan sprays, cheese food, cake decorations)

8. Miscellaneous Products

   (Other products not listed above)

Example formulations of several of these products are presented in Appendix H.

GENERIC GUIDELINES AND FACTORS THAT AFFECT FORMULATIONS

This section discusses some characteristics of hydrocarbon propellants as they relate to formulations and performance.

Hydrocarbons require changes in formulations and values to evaporate at the proper rate and yield the preferred spray. For example, the "transfer efficiency" of an antiperspirant spray with straight isobutane propellant was about 55%, versus over 80% when propelled by CFCs. In some cases, less volatile hydrocarbons such as n-butane or isopentane may provide the same effect as CFCs.

For certain products such as paints, lacquers, and industrial products, less expensive liquified petroleum gases (LPG) may be used. In these specific applications, the stronger odor of LPG is not a problem.

The most difficult problems of reformulating aerosol products with hydrocarbons have been solved. For example, in the U.S., problems with perfume formulations were solved by: 1) developing concentrates that were more compatible with the hydrocarbon propellants; 2) adding up to 18% water to help separate insoluble components; and 3) purifying the hydrocarbon propellants to remove the objectionable olefinic species by use of molecular sieves (3).

Dispersancy, one major attribute of aerosol propellants, is the efficiency with which a propellant can produce a fine spray or an acceptable foam. This is illustrated in Table 23.

The dispersancy of blends can be readily calculated. For example, Propellant A-46 (20 mol% propane and 80 mol% isobutane) has a dispersancy of [549 x 0.2 + 415 x 0.8] = 442 mL/g at 21.1°C.

TABLE 23. DISPERSANCY CHARACTERISTICS OF VARIOUS PROPELLANTS
(In order of Vapor Volume in mL/g)

Propellant	Vapor Volume (mL vapor/g liquid at 21.1°C)	Vapor Volume (mL vapor/mL liquid at 21.1°C)
Nitrogen	862	N/A
Carbon Dioxide	549	N/A
Nitrous Oxide	549	N/A
Propane	549	280
Dimethyl Ether	523	345
Isobutane	415	234
n-Butane	415	239
HFC-152a	365	333
HCFC-22	279	337
CFC-115	256	(not available)
HCFC-142b	240	269
HFC-134a	236	283
HCFC-141b	206	253
CFC-12	200	265
CFC-125	198	227
CFC-11	176	261
HCFC-124	176	242
HCFC-123	158	232
CFC-114	141	207
FC-C318	119	179

NOTE: These propellants boil at >21.2°C (Range: 23° to 33°C).

N/A = Not Applicable

A shave cream or mousse made using either 8% CFC-12/114, 4% A-46, or 2% nitrous oxide will all show the same properties of foam density and overrun. (However, the nitrous oxide formula will have a very high pressure, which can be expected to decrease significantly with use.)

In the years before the CFC aerosol ban of 1978 in the U.S., hair sprays were commonly formulated with 45% CFC-12/11 (55:45) or 40% Propellant A (10% isobutane, 45% CFC-12, and 45% CFC-11). They are now formulated with 20 to 26% isobutane, sometimes with a small amount of propane added. These examples show the importance of dispersive effect on propellant volume.

The dispersive effect is not linear but is modified by vapor-pressure, solubility factors, and even by the pressure itself. It normally can be used as a general guideline to determine equivalencies when changing from one propellant choice to another.

After a concentrate has been tentatively developed, the correct type and amount of propellant must be added, and an aerosol valve must be used that will develop the desired spray pattern or foam puff. One of the most important characteristics that the formulator looks for is particle size distribution, which can be of paramount importance. If the droplet size is too coarse, it can be decreased by one of the following techniques:

- Increase the percentage of propellant;
- Increase propellant pressure and/or dispersancy;
- Use a vapor-tap valve or a larger vapor-tap orifice;
- Use a mechanical break-up button;
- Add a low-boiling (volatile, easy breakup) solvent; and
- Reduce the quantity of polymers, thickeners, resins, adhesives, and water.

Approximately 40-50% of the world's 8 billion aerosol products use vapor-tap valves. Such valves have an orifice extending through the side or bottom wall of the valve body and into the head space area. When the orifice of a vapor-tap valve is enlarged to decrease particle size, a price is paid. The negative effects are listed below:

- A broader particle size distribution will generally result.
- A gradual coarsening of the spray may occur during use.
- The internal pressure will decrease, as air and the more volatile propellant ingredients preferentially escape through the vapor-tap orifice.
- The delivery rate will always be lower than without a vapor-tap, and will decrease during use, because of pressure reduction.

The potential problems with vapor-tap valves can be minimized by the following techniques:

- Use the smallest vapor-tap hole that will suffice (a 0.25 mm size may be a good starting point).
- Use a fairly large amount of propellant that disperses well (reservoir effect).
- Use a pure propellant; otherwise, the more volatile ingredient will be preferentially discharged, causing a pressure drop.
- Use reasonably large liquid orifices.
- Emphasize any or all of the above in taller cans, since (near emptiness) a liquid column of 150 - 250 mm will have to be maintained in the dip tube just to bring the product into the valve

chamber. A greater dynamic pressure potential is needed, compared with shorter can sizes.

As a rule, thin or driving sprays, or sprays with high delivery rates, will be perceived by consumers as "wet" or "cold," although they may be anhydrous. Wet sprays are usually disliked, except for the coating of inanimate surfaces (such as a paint spray or bug killer); they are most disliked for cosmetic items designed to be sprayed on the skin, such as underarm antiperspirants or deodorants. The aerosol antiperspirant provides an interesting challenge because large valve orifices must be used to prevent possible valve clogging by the 7 to 12% aluminum chlorohydrate powder normally present. Here, the vapor-tap valve, used with a mechanical break-up button, provides a fine-particled spray. The propellant content is in the 68-82% range to give good breakup and to provide an adequate reservoir for the vapor-tap.

Flammability

To devise a good aerosol product, a formulator must try to minimize the risks of flammability and possible explosivity. It is a tribute to the excellence of the aerosol packaging form that extremely flammable products can be safely dispensed, if the user follows the label directions, and if the formulator is able to make allowances for reasonably foreseeable consumer misuse. Flammability is a potential problem when large amounts of product are discharged at one time, as in some hair spray applications, painting, waterproofing, and in the total release insect fogger (TRIF) products. Flammability has also been a problem when containers are dropped on the valve stem, causing it to bend or crack in such a way that the valve jams, releasing a continuous spray.

Pressure

Most U.S. aerosols are formulated to a pressure as low as is consistent with good operational performance across the anticipated temperature range of their use. For example, hair sprays are expected to work well between 13° - 37°C, and reasonably well just outside these limits.

Pressure limits for containers vary only modestly among countries. In the U.S., the so-called ordinary or non-specification can is permitted to hold product with pressures up to 1,067 kPa abs. (9.85 bar - gauge) at 54.4°C. It will not rupture below 1,546 kPa abs. (14.8 bar - gauge). Special cans with 14% and 28% higher pressure ratings are also available at an extra cost. They only hold about 9% of the market. Aerosols of less than 118 mL capacity are not regulated for pressure limits in the U.S. Most aerosol containers will begin to deform at about 65°C and will rupture at 75°C or higher, depending on can and product.

Materials Compatibility

The formulator's job is not complete when an acceptable product and packaging system has been developed. Test packing is always needed to establish data on weight loss rates, can and valve compatibility, organoleptic stability, etc. Hundreds of sad stories could be written about new products that were inadequately tested, and then could not be manufactured, eroded the can, demulsified, changed color or odor, were subject to microbial proliferation, grew inorganic crystals, or eventually threw down resinous precipitates in the container, swelled valves shut or partly shut, blistered can linings, became latent leakers, etc. No fewer than 36 cans per variable should be test packed and checked--some at about 25°C and some at 40°C; some upright and some inverted.

Tinplate cans do not corrode unless at least 0.008% of free water is present. Above about 0.250%, greater concentrations of water will have no additional effect on the rate of corrosion, if any. Water has little effect on aluminum cans. In fact, its virtual absence can sometimes allow anhydrous alcohol (C_2H_5OH) to attack aluminum cans to produce aluminum ethoxide [$(C_2H_5O)_3Al$] and hydrogen (H_2) gas. Water is implicated in the well-known ability of 1,1,1-trichloroethane to sometimes attack plain and lined aluminum cans, but the mechanism is still unclear. Finally, water can facilitate development of high pH values in hair depilatory formulas and certain others, leading to aluminate (AlO_2^-) ion formation, plus hydrogen (H_2) gas. Since aluminum is amphoteric, it should only be used with formulas having a pH of less than 12.0 at 25°C, and then only when reliably lined.

If a generalized, non-pitting corrosion pattern is seen, it is best to use a lined or double-lined can. Detinning is generally a good sign, showing that the tin (not the iron) is anodic. If pitting is detected, the formula should be changed. Several options are described below:

- Remove the offending or causative ingredient if possible, such as sodium lauryl sulfate, especially if chloride ion is present.

- Add corrosion inhibitors, such as sodium nitrite, sodium benzoate, morpholine, or sodium silicates. (Do not use nitrites in conjunction with primary or secondary amines, or N-nitrosamines will very slowly form in situ. Many of these are carcinogenic.) From 0.05% to 0.20% inhibitor is generally sufficient.

- Increase the pH to between 7.6 and 8.8, if possible, by adding triethanolamine or ammonia (NH_4OH Solution).

- Remove or minimize ionizing materials, i.e., those that permit electroconductivity and thus promote galvanic corrosion reactions.

- Minimize chloride ion (especially). It is a very active corrosion promotor, even for underfilm corrosion. It is critical to minimize chloride ion when materials such as sodium lauryl sulfate (which contains it in some grades) or lauryl polyoxyethylene sulfates are present.

- Sometimes specific corrosion inhibitors are required. Sodium lauryl sarkosinate and sodium coco-B-aminopropionate surfactants are useful for sodium lauryl sulfate. Coco-diethanolamide is good for non-ionic surfactants. Virco-Pet 20 (composition proprietary, except that it is an organic phosphate), is good for dimethyl ether and water compositions.

- For some formulas, traces of moisture can be removed by using such scavengers as propylene oxide or epichlorohydrin. (Very limited evidence suggests that both may be mutagenic.) These chemicals are never recommended for cosmetics.

Many formulations that are intensely corrosive to steel cans may be conveniently packaged in lined aluminum containers. Examples are mousse products and saline solutions. The latter contain 0.9% sodium chloride (NaCl) in water under nitrogen pressure.

CAN/SPRAYER CHOICES

Successful marketing of a new or reformulated product depends on the stability and performance of the complete package system. Typically, this involves selecting formulations that have been tested for periods of a year or more. Potential problems that can be avoided include: corrosion of the container, instability of emulsions, changes in color or odor, microbial growth, crystallization or precipitation of insoluble compounds within the container, swelling of valves, or blistering of can linings (14). Failing to select the right reformulation of a product can be disastrous.

Converting from a CFC-propelled formulation to hydrocarbon-propelled formulation does not generally lead to problems with tinplate can corrosion. However, it is possible that a reformulated hydrocarbon-propelled product might require the addition of water, which could cause can corrosion.

On the other hand, there are instances when conversion away from CFCs to hydrocarbon propellants reduces the potential for corrosion. CFC-11 is known to readily hydrolyze to form corrosive HCl; this is possible in otherwise anhydrous formulations because of the use of 190-proof alcohol (95% alcohol and five percent water).

Aluminum containers are somewhat more prone to corrosion than tinplate containers, because aluminum is a very active metal and has unique corrosion properties. Therefore, many chlorinated solvents or propellants should not be used in unlined aluminum cans. Chloride ion is a strong corrosion promoter, especially in acidic solutions (3).

Both tinplate and aluminum containers can be protected from corrosive formulations by using sprayed can linings. Tinplate cans are available in the U.S. with nine different coatings. Three-piece tinplate cans have a side-seam stripe, whereas aluminum cans are impact-extruded and seamless. The integrity of the lining in these "monobloc" aluminum containers is far superior to that of most tinplate containers, since there is no subsequent bending or welding. Two examples of common coatings are Epoxy-Phenolic and Organasol.

Aerosol valve manufacturers state that valve selection is highly product-specific, and that no generalizations can be made about the effect of propellant conversion on the optimum aerosol valve.

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32. Chemical Specialties Manufacturers Association. Aerosol Pressurized Products Survey United States 1989. Order SR-2. CSMA, Washington, D.C.

APPENDIX A

INDUSTRY EXPERTS

INDUSTRY EXPERTS

General Area	Company Name	Contact Name and Title	Address	Phone	Fax
1. Hydrocarbon Propellant Suppliers	Aeropres	Dr. Harry McCain Technical Director	1324 N. Hearne Suite 200 Shreveport, LA 71107 USA	318-221-6282	
	Calor Gas Ltd.	K.A. Bromboszcz General Manager - National Sales	Appleton Park Slough, SL3 9JG England	(0753) 40000	(0753) 48121
	Diversified CPC International, Inc.	Mr. Bala Nathan	Santa Fe Industrial District Durkee Road Channahon, IL 60410 USA	815-423-5995	815-423-5627
	Industrial Hydrocarbons	--	175 W. Bonita Ave. San Dimas, CA 91773 USA	714-599-8386	
2. Container and Valve Suppliers	Advanced Monobloc	Mr. Scott Schneider	Hermitage, PA, 16148 USA	412-981-4420	412-342-1116
	Precision Valve Corp.	Mr. William Gregg Vice President, R&D	700 Nepperham Ave. P.O. Box 309 Yonkers, NY 10702 USA	914-969-6500	914-969-1985
	Valvulas de Precision, S.A.	Geno Nardini Marketing Director	Azafran 313 Col. Granjas Mexico Mexico, D.F. CP 08400 Mexico	654-99-16 654-99-57	654-19-59
	Seaquist Valve Co. (Div. of Pittway Corp.)	Ms. Carleen Krieder Vice President, R&D	1160 N. Silver Lake Rd. Cary, IL 60013 USA	708-639-2124	708-639-1179
	U.S. Can	Mr. Paul Hrubesky	900 Commerce Drive Oak Brook, IL 60521 USA	708-888-5673	708-888-5680
3. Equipment Manufacturers	Aerofill Ltd. (Filling Equipment)	Mr. R. L. Russell Mechanical Projects Manager	33-35 Clayton Road Hayes Middlesex UB31RU England	081-848-4501	081-561-3308
	Coster Technologie Speciali SpA (Filling Equipment)	Mr. Giancarlo Bacchetta	Via Fabio Filzi 27 20124 Milan Italy	392 669 84764	
	The Kartridg Pak Co. (Filling Equipment)	Mr. Herb Page	807 W. Kimberly Road P.O. Box 3848 Davenport, IA 52808 USA	319-391-1100	319-391-4951
	Terco (Filling Equipment)	Mr. Dave Cull	496 Lunt Ave. Schaumburg, IL 60193 USA	708-894-8828	708-894-8846
	Fike Corporation (Explosion Suppression)	Mr. Bruce McLelland EPG Product Manager	704 S. 10th Street Blue Springs, MO 64015 USA	816-229-3405	816-228-9277

(Continued)

INDUSTRY EXPERTS (Continued)

General Area	Company Name	Contact Name and Title	Address	Phone	Fax
3. Equipment Manufacturers (Cont.)	Fenwal Safety Systems, Inc. (Explosion Suppression)	Mr. Henry Garzia System Design Mgr.	700 Nickerson Rd. Marlborough, MA 01752 USA	508-481-5800	508-485-3115
	Kiddle Graviner Ltd. (Explosion Suppression)	--	Polye Road Colnbrook Slough, Berkshire SL30HB England	44753683245	44753685126
	LaRoche Chemicals, Inc. (Activated Aluminas for LPG Purification)	Dr. John W. Novak, Product Mgr.	Airline Hwy. P.O. Box 1031 Baton Rouge, LA 70821 USA	504-356-8423	504-358-2820
	Alcoa Separations Technology, Inc. (Subsidiary of ALCOA) (Activated Aluminas and Activated Carbons for LPG Purification)	Mr. Hugh B. Walker, Regional Sales Mgr.	333 North Belt Suite 650 Houston, TX 77060 USA	713-999-6050	713-999-5403
	Davison Chemical Division (W.R. Grace & Co.) (Silica Gels and Molecular Sieves for LPG Purification)	Mr. George W. Alsfeld Technical Sales Rep.	P.O. Box 2117 Baltimore, MD 21203-2117 USA	301-659-9292	301-659-9213
	UOP Molsiv Adsorbents (Molecular Sieve Adsorbents for LPG Purification)	Mr. Michael E. Clark Technical Sales Rep.	13105 Northwest Fwy. Suite 600 Houston, TX 77040 USA	713-744-2840	713-744-2802
4. Consultants	Montfort A. Johnsen & Assoc., ltd.	Montfort A. Johnsen Aerosol Consultant	26 Sheral Drive Danville, IL 61832-1354 USA	217-442-1400	217-442-1400 X228
	Richard C. Knollys	Richard C. Knollys Aerosol Consultant	Greys Manor Road Goring on Thames Reading, Berkshire: RG8 9ED England	0491 873094	44734845865 c/o CMB Aerosols
5. Plant Operators	Spray Quimica C.A.	Jose Pons Pons General Manager	La Victoria Venezuela	5844213753	5844210521
	Toyo Aerosol Industry Co. Ltd.	Katsuo Imazeki	Saiwai Building 1-3-1 Uchisaiwaicho Chiyoda-ku, Tokyo 100 Japan	81-3-502-1292	81-3-508-8685

(Continued)

INDUSTRY EXPERTS (Continued)

General Area	Company Name	Contact Name and Title	Address	Phone	Fax
6. Government Officials	Egyptian Environmental Affairs Agency	Dr. El-Mohamady Eid Chairman of EEAA	Arab Republic of Egypt Cabinet of Ministers 11-A Hassan Sabry St. Zamalek, Cairo Egypt	20-2-341-1323	20-2-342-0768
	Ministry of Light Indust. Dept. of Intl. Cooperation	Mr. Zhangxi Hunag Chairman, Aerosol Technical Subcommittee	22b Fu Wai Da Jie Beijing, 100833 China	86-1-867-940	222717 LIMDI CN (telex)
	Ministry of the Chemical Industry	Vitaly Pulikov	Kirov St. 20 101851 Moscow USSR	927-7363	411009 BIUR SU (telex)
	U.S. EPA Office of Air & Radiation Global Change Division	Stephen O. Andersen, Ph.D.	Mail Stop ANR-445 401 M Street, S.W. Washington, D.C. 20460 USA	202-475-9403	202-382-7883
	U.S. EPA Air and Energy Engineering Research Laboratory Stratospheric Ozone Protection Branch	N. Dean Smith, Ph.D.	Air and Energy Engineering Research Laboratory MD-62B Research Triangle Park, NC 27711 USA	919-541-2708	919-541-7885

APPENDIX B

SAMPLE CALCULATIONS

SAMPLE CALCULATIONS FOR LPG PURIFICATION

BASIS:

1) Assume a large-size automated aerosol filling plant producing approximately 10 million cans per year
2) Assume each unit contains approximately 30% by volume HC propellant
3) Assume an average unit size of 12 fluid ounces
4) Assume production schedule of 250 days per year with 8 hour per day shifts

A. PRODUCTION RATE: $(10\text{x}10^6$ units/yr)/(250 day/yr)= 40,000 units/day
or (40,000 units/day)/(8 hour/day shift)= 5,000 units/hr

B. LPG CONSUMPTION RATE: (30 vol% propellant)*(12 fl. oz)*(5,000 units/hr)/(128 oz./gallon)
= 141 gal/hr LPG

(Round up to 150 gal/hr) → (150 gal/hr)*(8 hr/day)*(21 day/mo)
= 25,200 gal/mo LPG
(150 gal/hr)*(4.695 lb/gal) = 705 lb/hr

Given that a large tanker load may have a capacity of 10,000 gallons but may only be filled to 80 or 90 percent of full, this hypothetical plant would receive a shipment approximately once each week.

C. DEHYDRATION

Take water content in hydrocarbon as 0.018 lb H_2O/100 lb HC at 100°F for isobutane (from Figure 3 "Solubility of Water in Hydrocarbons" in ALCOA Bulletin "Dehydrating Liquids with Alcoa Activated Aluminas" Form No. F35-14481)

Use value of 2 wt% H_2O capacity for silica gel when drying to 0°F Dew Point (from Figure 5 "Silica Gel Bed Temperature at Various Water Loadings" in Davison Silica Gels Brochure IC-15-1087)

Assume operation at 100°F: (705 lb/hr)*(0.018 lb H_2O/100 lb HC)
= 0.127 lb H_2O/hr

Required Amount of Silica Gel for 0°F Dew Point:

Assume Silica Gel replacement every 3 months: (3 mo.)*(21 days/mo.)*(8 hr/day) = 504 hrs between regeneration/replacement

Required Silica Gel = (504 hr)*(0.127 lb/hr)/(2 lb H_2O per 100 lb Silica Gel) = 3,200 lb of Silica Gel

Approximate bed dimensions: Assume density of 35 lb/ft^3
Bed Volume: (3,200 lb)/(35 lb/ft^3)= 91.4 ft^3
(This could be accommodated with a bed of 4 ft. diameter and 7 ft. deep)

Approximate Cost of Silica Gel Charge: Assume unit cost of $3.00 per pound (per U.S. supplier at 1,200 pound minimum shipment) = (3,200 lb)*($3.00/lb) = $9,600 per charge every 3 months.

(Continued)

SAMPLE CALCULATIONS (Continued)

D. DESULFURIZATION

Take sulfur content in hydrocarbon as 10 grains H2S/100 ft^3 HC (equals 150 ppmv) (sulfur content is highly variable depending on local LPG supply and odorization: for example, the U.S. standard for commercial propane and butane is 15 grains per 100 ft^3, while the odorization limit using ethyl mercaptan is approximately 2 grains per 100 ft^3).

Convert to parts-per-million (weight): 10 grains = 0.0014286 lb and (100 ft^3 isobutane)/(6.529 ft^3/lb at Std. Cond.) = 15.316 lb

H2S (ppmw)= (0.0014286 lb H2S)/(15.316 lb gas)*(10^6) = 93.3 ppmw H2S

Use value of 3 wt% H2S capacity for Type 13X Molecular Sieve when treating at 77°F (from Isotherm Data Sheet No. 207 "Hydrogen Sulfide Adsorption on 13X Pellets" in Union Carbide Molecular Sieves Materials Data Sheets XF-19)

Assume operation at 77°F: (705 lb/hr)*(93.3 lb H2S/10^6 b HC)= 0.0658 lb H2S/hr

Required Amount of Type 13X Molecular Sieve for H2S Removal:

Assume Mol Sieve replacement every 3 months: (3 mo.)*(21 days/mo.)*(8 hr/day) = 504 hrs between regeneration/replacement

Required Type 13X Mol Sieve = (504 hr)*(0.0658 lb/hr)/(3 lb H2S per 100 lb Mol Sieve) = 1,100 lb of Type 13X Molecular Sieve

Approximate bed dimensions: Use bulk density of 40 lb/ft^3
Bed Volume: (1,100 lb)/(40 lb/ft^3)= 27.5 ft^3
(This could be accommodated with a bed of 2 ft. diameter and 9 ft. deep)

Approximate Cost of Type 13X Mol Sieve Charge: Assume unit cost of $3.00 per pound (per U.S. supplier at 1,200 pound minimum shipment)

= (1,100 lb)*($3.00/lb) = $3,300 per charge every 3 months.

APPENDIX C

SAFETY CHECKLIST FOR AEROSOL PLANTS USING HYDROCARBON PROPELLANTS

SAFETY CHECKLIST FOR AEROSOL PLANTS USING HYDROCARBON PROPELLANTS

A. RECEIVING, STORAGE, AND HANDLING

NOTE: This section refers to the receiving, unloading, transfer, and storage of flammable hydrocarbon propellants at the aerosol manufacturing plant site. Minimum hydrocarbon propellant storage for any filling plant is usually 10,000 gallons (37,850 L).

SAFETY CHECKLIST:

- Storage tanks should be located at least 50 feet (15.2 m) from property lines and important buildings.
- An unloading station should be at least 10 feet (3.05 m) from the storage tanks.
- The unloading and storage area should be maintained in a fenced area with two emergency exits (both unlocked whenever personnel are in the area).
- Unloading compressors or pumps should be mounted on a concrete base and kept fairly remote from tanks or other pumps. Pumps may also be located within a separate pump house equipped with gas detection and fire extinguishing equipment.
- All electrical equipment within 15 feet (4.57 m) of any outside hydrocarbon propellant storage tank, bulk trailer truck, or interconnecting piping must be explosion-proof (U.S. National Electrical Code, Class I, Group D, Division 2) and be grounded. [Equipment within 5 feet (1.52 m) must be Div. 1.]
- The land should be kept free of grass and weeds and should have no low spots. Air should move freely across it to disperse any possible vapors.
- Shut-off valves at the tank should be accessed readily. Shut-off valves, emergency shut-off valves, and back-flow check valves should be used in conjunction with the liquid inlet, liquid outlet, and vapor lines. Excess flow valves should be installed in all openings in the storage tank except the pressure relief valve, gauging, and liquid fill connections.
- Storage tanks should have pressure gauges, thermometers, and liquid level gauges as per requirements specified in the American Petroleum Institute-American Society of Mechanical Engineers (API-ASME) Code for Unfired Pressure Vessels for Petroleum Liquids and Gases. Minimum design pressure for propane storage tanks is 250 lbs/sq. inch-gauge (17.2 bar). It is recommended that this design pressure be utilized for butane tanks as well to provide a more

flexible operation even though butane tanks can be designed for 125 lbs/sq. inch-gauge.

- Tanks should be painted in a white, silver, or pastel color and marked as to contents.
- Water deluge cannons should be present to enable cooling of the tanks in the event of a fire.
- Pipelines should be laid out to allow for expansion of the metal and for expansion of liquid contents to prevent rupture between shut-off points. This is handled by hydrostatic relief valves in each section. Relief valves should be set to discharge at pressures no greater than 120% of the 250 lbs/sq. inch minimum allowable working pressure of the system.
- Pipes should be painted and labeled as to contents and flow direction and should be on pipe supports about two feet high from the ground.
- Ethanol storage tanks should be diked to contain the liquid in the event of a leak or spillage.

B. PROPELLANT FILLING OPERATION

NOTE: The safety items listed below particularly address requirements or recommendations for propellant filling and pump rooms (gashouses) physically separated from the main plant building. In instances where the propellant filling operation is conducted within a large enclosure also used for other operations such as liquid concentrate filling, can weigh-checking, and hot-tank leakage detection, the usual safety approach is to apply the items listed below to the entire area. Installations of this latter type must be designed with extreme care since a fire or explosion in such a large area could have far greater repercussions than if contained in a separate gas charging house.

SAFETY CHECKLIST:

- The propellant filling and pump room (gashouse) should be 25 ft (7.62 m) from any chemical storage and ignition source, and 50 ft (15.2 m) from any property line. It should be of minimum size, and be on the ground floor with no basement or other open spaces, large sewers, or other voids beneath the building. The propellant filling/pump rooms should be physically separated from the main plant buildings by at least 5 feet (1.52 m) or by noncommunicating walls (for example, no penetration of a common wall between the propellant filling room and main production room by a conveyor line).
- An ignition-free condition must be maintained within 25 feet (7.62 m) of all openings to the propellant filling room. This means that electrical requirements, including light fixtures, must

be Class I, Group D, Division 1 or 2 (classification of the U.S. National Electrical Code).

- The propellant filling room should be constructed with three rather substantial walls, preferably of concrete [minimum strength 100 lbs/sq. ft (288 kg/sq. m)], plus a fourth wall that contains large "blow-out" panels. These insulated steel panels should be light-weight and shear-bolted to the wall frame so that they can blow outward at internal pressures of about 25 to 30 lbs/sq. ft (122 to 146 kg/sq. m). A roof is not recommended as the primary pressure release point since the roof generally supports sprinkler systems and should continue to support them in the event of an explosion. Also, in cold climates, snow and ice accumulations on the roof could hamper explosion relief. The "blow-out" panels should be positioned in such a manner that they will not strike pipelines or other structures which could result in intensifying the problem when the panels are blown outward.

- Floors are constructed of concrete reinforced with steel bars. The upper layer may be impregnated with carbon to render the floor conducting and prevent static charge buildup. This property may be enhanced by placing a welded metal screen just below the finished surface. Alternatively, the floor may be coated with a nonconductive, nonslip synthetic material.

- Ventilation is the key to fire/explosion prevention. It is important to maintain the filling room at a slight negative air pressure. The ventilation system changes the air in a propellant filling room a minimum of once every minute, and should be spark- and explosion-proof. Air flow monitors should be installed in the propellant filling room to warn if too little air is moving through it. Another guideline is that ventilation should be provided at a rate of 1 cfm/sq. ft (0.3 m^3/min per sq. m) of filling room area.

- The ventilation system should allow for an air sweep at floor level since combustible gases are heavier than air and tend to accumulate in low places.

- The exhaust of the ventilation system should be physically located at a good distance (at least 10 feet; 3.05 m) from the air intake ports to prevent re-entry of exhaust gases into the building(s).

- Rain caps are not recommended for exhaust stacks because they tend to restrict high velocity air flows and deflect vapors back into the room.

- A room air exchange rate of once per minute will not prevent an explosion in the event of a serious rupture in an unprotected gas line. Therefore, hydrocarbon sensing devices should be installed at two or three locations in the gashouse to detect a rise to 20% of the LEL (Lower Explosion Limit) value (about 0.4% gas) to trigger an alarm and activate an interlock system which causes the ventilation rate to be doubled or tripled. Note that the gas detection heads should be positioned to determine any buildup of gas within the room itself, rather than to determine the source of gas discharge from equipment. Usual locations are below the conveyor openings into the gashouse from the main building and above the ventilated flow of air across the gassing room floor. When the hydrocarbon detector system senses a rise to 25-50% of the LEL value (40% is usual), a different alarm should be activated (both visual and audible), the gasser shut down automatically, and the hydrocarbon inlet line automatically closed by a solenoid-operated valve.

- Local exhaust ventilation at all propellant gassers may replace up to 75% of the volumetric flow rate of the ventilation required.
- Doubling or tripling the ventilation rate in the propellant filing room necessitates that sufficient air intakes be installed for operation during the time of excess ventilation. Steam or hot water (from a remote boiler) heating of the gas room may be required to keep the work area comfortable and the equipment from freezing during cold weather and episodes of high ventilation. Alternatively, heat may be supplied to the gashouse via an insulated duct of tempered air from the separate main plant building. When this approach is taken, it is important to consider the balance of ventilation air necessary to maintain the room at a slight negative pressure.
- The gas detection system should be fail-safe so that if the sensor becomes inoperative, the gasser will be shut down and the gas line shut off until the problem is corrected.
- Gas detectors must be calibrated daily with a known amount of gas and records should be kept on these calibrations.
- The gasser inlet line should be protected by one or two excess flow valves, so that even if a serious rupture occurs, the flow increase would act to shut off the gas supply.
- Since propellant leaks are not uncommon at the gasser machine itself, the closest excess flow valve should be located quite near the machine without any accumulators, large diameter pipes or other high capacity line components in between. Relief valves are required between any two shut off valves.
- All gasser hoses must be fully conductive.
- All rotating tables and conveyor equipment must be statically grounded and bonded.
- Enclosing the gasser machine with a separate ventilation and fire detection system can provide an additional margin of safety. This

ventilation system should allow for at least 5 air changes per minute through the enclosure during normal operation.

- It is desirable to maintain the propellant filling room relative humidity at approximately 65% to reduce buildup of static electricity. The humidification may be accomplished by steam from the plant boiler. The steam should be released above the work area near the room center. Additional humidification may not be necessary when steam jets are in use to de-ice gasser heads. Use of moist air from the hot-tank exhaust system is not recommended since such air may be contaminated with flammable gas.

- Gashouse personnel should wear antistatic clothing.

- The propellant filling and vacuum pump room(s) should have a fire extinguishing system. This system may have detection devices which respond to pressure or heat and react to fires by activating water sprinklers. Note: In cases where the propellant filling/pump rooms are located within the main plant building where explosion venting via "blow-out" panels may not be practical, an Explosion Suppression System is recommended. (A nonhalon system is preferred providing one can be suitably designed for the specific situation.)

- The sprinkler system should be attached to the structural beams supporting the roof, not to the roof itself.

- It is desirable to have the propellant filling room/gashouse equipped with a crack resistant plastic window and/or with an open explosion-proof loudspeaker to allow the gassing room operator to be seen and/or heard at all times.

- The door to the gashouse should have a Class A fire rating and be installed in accordance with U.S. National Fire Protection Association (NFPA) Standard No. 80. The door should be fitted with spring, friction, or magnetic latches to allow easy egress in the event of an emergency. The door and latch mechanism should be doubly grounded to eliminate static charge buildup. An "open door" alarm system should be installed to sound an alarm whenever the door is left open for more than 15 seconds. This is necessary since an open door can adversely affect the floor-sweeping ventilation system.

- If the propellant filling room has air conditioning ductwork that passes through a fire wall, the ductwork shall have fire dampers installed in accordance with NFPA Standard 90A.

C. HOT-TANK INSPECTION

NOTE: This section addresses the production area wherein the propellant charged cans are immersed in a tank of hot water (57-66°C) for visual inspection of leakage, can distortion, or rupture.

SAFETY CHECKLIST:

- The hot tank should be fitted with an explosion-proof hood covering the entire trough length. The hood and exhaust duct may be constructed of stainless steel to minimize possible corrosion from the moist air and vapors emanating from the hot tank. The minimum capacity of the exhaust blower should be 4,000 cubic feet per minute (113,000 liters/min.)

- It is recommended that all electrical systems in the near vicinity of the hot tank be explosion-proof. Electrical equipment located within the enclosure shall be Div. 1, and equipment located within 5 feet (1.52 m) shall be Div. 2.

- Hydrocarbon gas detectors may be desirable at the hot tank, located below the tank to detect leakage of flammable vapors into the main production room.

D. LIQUID COMPOUNDING

NOTES: Most plant fires arise in connection with either the hydrocarbon propellants or the aerosol "concentrate" (usually containing ethanol or petroleum distillates although other flammable components may sometimes be employed such as methyl ethyl ketone, methanol, isopropanol, and methyl isobutyl ketone). The usual cause of a fire in the liquid compounding area of a plant where the concentrates are blended is the ignition of the air/vapor mixture by a spark from an electric motor, switch, or static electricity.

SAFETY CHECKLIST:

- Whenever heating the concentrate mix is desired to bring about an emulsion, the heating must be done in a completely closed, pressure-tight tank and with no electrical equipment within at least 30 feet (9.1 m) unless such equipment is explosion-proof. Also, the mixing tank should not be opened until the completed emulsion has been cooled to below 100°F (38°C).

- The primary defense against concentrate fires is proper ventilation. Exhaust registers should be located near compounding tanks, preferably below the rim to remove any vapors escaping from the top of the tank.

- Supplementary building heat may be needed in winter months to offset the cold air being brought into the building via the plant exhaust system. Steam, supplied from a remote boiler, is recommended for heating purposes.

- Fire hoses and extinguishers should be strategically located in the compounding area in addition to the room sprinkler system.

E. QUALITY ASSURANCE/PRODUCT DEVELOPMENT LABORATORY

NOTE: Laboratory operations involve safety concerns often equivalent to those associated with the propellant filling operation. It is more practical for the laboratory operation, however, to address safety by specific laboratory work area rather than for the entire laboratory as a unit.

SAFETY CHECKLIST:

- Ventilation should be by an enclosed, high ventilation, explosion-proof hood where a sample is placed whenever flammable gases are being used as well as by general laboratory ventilation which forces an air exchange for the entire room. The explosion-proof area should extend about 8 feet (2.5 m) from the hood. This means that nonexplosion-proof laboratory instruments and telephones should not be located within this area. Reasonable ventilation and explosion-proof electrical systems must be provided wherever quantities of finished products are stored for testing.

- Any hood used for other than very small-scale operations should be equipped with a flammable gas detection system (hot-wire type). A portable fire extinguisher should be located nearby.

- The laboratory should have separate instrument and hazardous storage areas. Gas cylinders ideally should be permanently stored in an outside hazardous storage area such as a gas shed constructed of metal posts and galvanized sheet metal on a concrete pad. A ventilation gap of about 6 inches should exist around the bottom of the shed walls. One side of the shed is generally left open for access. Stored cylinder should always have the cylinder on-off valve tightly closed, the outlet plugged with the brass fittings made for that purpose, and have the protective cap in place. The refilling of smaller cylinders from larger ones for use in the laboratory is not recommended. Ideally, the gas should be piped into the laboratory from a working cylinder stationed outside and restrained in place by a length of chain bolted to the exterior wall.

- At the work area, a manifold can be installed with quick-disconnects to facilitate the changing from one propellant to another. An exhaust pipe should be run from the manifold to the vent.

- Flammable solvent storage units should be located away from heavily trafficked areas, in a reasonable vented area, and distant from electrical equipment and sources of heat.

- Personnel should be trained in proper lab safety procedures.

- Fire extinguishers should be placed at strategic locations.

F. DISPOSAL OF REJECTED/UNWANTED AEROSOLS

NOTE: This refers to the disposal of rejected products; either leakers, R&D samples, quality control samples, or defective products (overfills, low weights, unacceptable performance, incorrect ingredient assay, etc.). This can amount to several thousand rejected aerosol units per day for large fillers.

SAFETY CHECKLIST:

- Collection drums or bins for rejected dispensers should be kept outside and fed through a chute wherever possible. Otherwise, collection receptacles should be transported outside at frequent intervals. While in the production plant area, collection receptacles should be fitted with flexible plastic exhaust hoses connected to an exhaust system such as serves the hot tank area.
- Aerosols containing flammable gases should not be destroyed indoors. When more than 5 containers need to be evacuated at one time, the procedure should be conducted within the propellant filling room or outdoors, and the containers should be grounded.
- Upon accumulation of 3 to 5 filled collection drums or bins (no more than 1000 aerosol), the containers should be moved to a remote outside disposal station.
- Aerosol shredders/crushers should be located in a remote, controlled access area at least 100 feet (30.5 m) from the nearest building and at least 50 feet (15.2 m) from any property line. Plant personnel should be kept at a safe distance from the disposal station when aerosol containers are being shredded or crushed. Fork lift transport trucks should likewise be kept at safe distances from the operating disposal unit.
- Liquid wastes released from the disposal of defective cans may be classified as either hazardous or sanitary wastes depending on properties and applicable regulations and must be processed according to approved procedures.

F. END OF PRODUCTION LINE TEMPORARY STORAGE

NOTE: This section refers to the storage of flammable aerosol products in production areas such as in staging areas where finished products await transfer to a warehouse.

SAFETY CHECKLIST:

- In general, no more than 4000 pounds (1816 kg) of Level 2 or Level 3* aerosol products per production line should be permitted in production areas and should be stored no more than one pallet-load high. NOTE: Warehouse storage of finished aerosol products is covered as a separate issue by U.S. National Fire Protection Association Code 30B (August 1990).

*Level 1 - Aerosols with base products containing up to 25% by weight of water-miscible or water-immiscible flammable materials.

Level 2 - Aerosols with base products containing:
a. From 25 to 100% of water-miscible flammable materials, or
b. From 25 to 55% of water-immiscible flammable materials

Level 3 - Aerosols with base products containing from 55 to 100% of water-immiscible flammable materials.

NOTE: The following additional considerations apply to the above definitions of Levels 2 and 3:

(1) When the weight of flammable propellant equals or exceeds 50% of the contents, the aerosol classification should be increased to the next higher level.

(2) When the weight of flammable propellant equals or exceeds 80% of the contents, the aerosol classification should be increased to Level 3, regardless of the composition of the base product.

(3) "Flammable" ingredients should be those having a flash point of 260°C by a closed cup flash point test.

APPENDIX D

REFERENCE ORDERING INFORMATION

REFERENCE ORDERING INFORMATION

1. National Fire Protection Association (NFPA) Tel 617-770-3000
1 Battery March Park Fax 617-770-0700
P.O. Box 9143
Quincy, MA 02169
USA

1990 National Electrical Code
Item GL-70-90SB $29.50 each

NFPA 30B: Manufacture and Storage of Aerosol Products (43 pp.)
Item GL-30B-90 $17.50 each

NFPA 58: Storage and Handling of Liquified Petroleum Gases (92 pp.)
Item GL-58-89 $19.50 each

Add $3.65 for shipping and handling on all orders

Payment Terms are Net 30 Days.

Payment Due in U.S. dollars.

2. Chemical Specialties Manufacturers Association (CSMA)
1913 Eye Street, N.W.
Washington, D.C. 20006
USA

Tel 202-872-8110
Fax 202 872-8114

Hydrocarbon, DME, and Other Propellants: Considerations for Effective Handling in the Aerosol Plant and Laboratory
Item TP-7 $85.00

Section Updates to Hydrocarbon Manual
Item TP-7A $10.00

Orders over $10.00 send invoice (Domestic orders only)

Foreign order - check required (in U.S. Dollars)

Checks payable to CSMA.

Multiple copy and foreign orders will be shipped F.O.B. Washington, D.C.

3. British Aerosol Manufacturers' Association (BAMA) Tel 071 828 5111
Kings Building Fax 071 834 8436
Smith Square Telex 916672 Chemin G
London SW1P 3JJ
UK

BAMA Guide to Safety in Aerosol Manufacture (2nd Ed.)

Cover Price: £25 sterling
Foreign Orders: £40 (including post and packing)

Orders accepted only when accompanied by full payment in sterling.

APPENDIX E

FEDERAL REGISTER METHODS FOR FLAME TESTING

SUBCHAPTER D—HAZARDOUS SUBSTANCES

PART 191—HAZARDOUS SUBSTANCES: DEFINITIONS AND PROCEDURAL AND INTERPRETATIVE REGULATIONS

Final Order

In response to the notice of proposed rule making published in the FEDERAL REGISTER of April 29, 1961 (26 F.R. 3705), extensive written comments were received. Subsequently, on July 13 and 14, 1961, an opportunity was afforded for the oral presentation of views on the proposed regulations. Following review of the comments received both in writing and at the oral presentation, and other relevant material, the Commissioner of Food and Drugs has concluded that the following regulations should issue with respect to hazardous substances pursuant to the provisions of the Federal Hazardous Substances Labeling Act (sec. 10, 74 Stat. 378; 15 U.S.C.A. 1269), and under the authority delegated to him by the Secretary of Health, Education, and Welfare (25 F.R. 8625):

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AUTHORITY: §§ 191.1 to 191.216 issued under sec. 10, 74 Stat. 378; 15 U.S.C.A. 1269. Additional authority is cited following section affected.

DEFINITIONS AND INTERPRETATIONS

§ 191.1 Definitions.

(a) *Act.* "Act" as used in this part means the Federal Hazardous Substances Labeling Act.

(b) *Commissioner.* "Commissioner" means the Commissioner of Food and Drugs, Food and Drug Administration, Department of Health, Education, and Welfare.

(c) *Containers.* "Container intended or suitable for household use" means any carton, bottle, can, bag, tube, or any other container which under any customary or reasonably foreseeable condition of purchase, storage, or use may be brought into or around a house, apartment, or other place where people dwell, or in or around any related building or shed, including but not limited to a garage, carport, barn, or storage shed. The term includes containers of such articles as polishes or cleaners designed primarily for professional use, but available in retail stores such as hobby shops for nonprofessional use. Also included are such items as antifreeze and radiator cleaners that, although principally for car use, may be stored in or around dwelling places. The term does not include industrial supplies that might be taken into a home by a serviceman. An article labeled as and marketed solely for industrial use does not become subject to this act because of the possibility that an industrial worker may misappropriate a supply for his own use. Size is not the only index of whether the container is "suitable for household use." The test shall be whether under any reasonably foreseeable condition of purchase, storage, or use the container may be found in or around a dwelling.

(d) *Prominently and conspicuously.* "Prominently" in section 2(p)(2) and "conspicuously" in section 2 (p)(1) and (p)(2) of the act means that, under customary conditions of purchase, storage, and use, the required information shall be visible, noticeable, and in clear and legible English. Some factors affecting a warning's prominence or conspicuousness are: Location, size of type, and contrast of printing against background. Also bearing on the effectiveness of a warning might be the effect of the package contents if spilled on the label. Unless impracticable because of the nature of the substance, the label shall be of such construction and finish as to withstand reasonably foreseeable spillage through foreseeable use. (See § 191.101.)

(e) *Highly toxic substances.* "Highly toxic" is any substance falling within any of the following categories:

(1) Any substance that produces death within 14 days in half or more than half of a group of white rats each weighing between 200 grams and 300 grams at a single dose of 50 milligrams or less per kilogram of body weight, when orally administered.

(2) Any substance that produces death within 14 days in half or more than half of a group of white rats each weighing between 200 grams and 300 grams when inhaled continuously for a period of 1 hour or less in an atmospheric concentration of 200 parts per million by volume or less of gas or vapor or 2 milligrams per liter by volume or less of mist or dust, provided that such concentration is likely to be encountered by man when the substance is used in any reasonably foreseeable manner.

(3) Any substance that produces death within 14 days in half or more than half of a group of rabbits weighing between 2.3 kilograms and 3.0 kilograms each, tested in a dosage of 200 milligrams, or less, per kilogram of body weight when administered by continuous contact with the bare skin for 24 hours or less by the method described in § 191.10.

The number of animals tested shall be sufficient to give a statistically significant result and be in conformity with good pharmacological practices.

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(4) Any substance determined by the Commissioner to be "highly toxic" on the basis of human experience.

(f) *Toxic substances.* "Toxic substances" is any substance falling within any of the following categories:

(1) Any substance that produces death within 14 days in one-half of a group of white rats each weighing between 200 grams and 300 grams, at a single dose of more than 50 milligrams per kilogram but not more than 5 grams per kilogram of body weight, when orally administered. Substances falling in the toxicity range between 500 milligrams and 5 grams per kilogram of body weight will be considered for exemption from some or all of the labeling requirements of the act, under section 191.62, upon a showing that, because of the physical form of the substances (solid, a thick plastic, emulsion, etc.), the size or closure of the container, human experience with the article, or any other relevant factors, such labeling is not needed.

(2) Any substance that produces death within 14 days in one-half of a group of white rats each weighing between 200 grams and 300 grams, when inhaled continuously for a period of 1 hour or less at an atmospheric concentration of more than 200 parts per million but not more than 20,000 parts per million by volume of gas or vapor or more than 2 milligrams but not more than 200 milligrams per liter by volume of mist or dust, provided such concentration is likely to be encountered by man when the substance is used in any reasonably foreseeable manner.

(3) Any substance that produces death within 14 days in one-half of a group of rabbits weighing between 2.3 kilograms and 3.0 kilograms each, tested at a dosage of more than 200 milligrams per kilogram of body weight but not more than 2 grams per kilogram of body weight, when administered by continuous contact with the bare skin for 24 hours by the method described in § 191.10.

The number of animals tested shall be sufficient to give statistically significant results and be in conformity with good pharmacological practice.

(4) Any substance that is "toxic" (but not "highly toxic") on the basis of human experience.

(g) *Irritants.* The term "irritant" includes "primary irritant to the skin" as well as substances irritant to the eye or to mucous membranes.

(2) The term "primary irritant" means a substance that is not corrosive and that the available data of human experience indicate is a primary irritant; or which results in an empirical score of five or more when tested by the method described in § 191.11.

(3) *Eye irritants.* A substance is an irritant to the eye mucosa if the available data on human experience indicate that it is an irritant for the eye mucosa, or when tested by the method described in § 191.12 shows that there is at any of the readings made at 24, 48, and 72 hours discernible opacity or ulceration of the cornea or inflammation of the iris, or that such substance produces in the conjunctivae (excluding the cornea and iris) a diffuse deep-crimson red with individual vessels not easily discernible, or an obvious swelling with partial eversion of the lids.

(h) *Corrosive.* A "corrosive substance" is one that causes visible destruction or irreversible alterations in the tissue at the site of contact. A test for a corrosive substance is whether, by human experience, such tissue destruction occurs at the site of application. A substance would be considered corrosive to the skin, if when tested on the intact skin of the albino rabbit by the technique described in § 191.11 the structure of the tissue at the site of contact is destroyed or changed irreversibly in 24 hours or less. Other appropriate tests should be applied when contact of the substance with other than skin tissue is being considered.

(i) *Strong sensitizer.* A "strong allergic sensitizer" is a substance that produces an allergenic sensitization in a substantial number of persons who come into contact with it. An allergic sensitization develops by means of an "antibody mechanism" in contradistinction to a primary irritant reaction which does not arise because of the participation of an "antibody mechanism." An allergic reaction ordinarily does not develop on first contact because of necessity of prior exposure to the substance in question. The sensitized tissue exhibits a greatly increased capacity to react to subsequent exposures of the offending agent. Thus, subsequent exposures may produce severe reactions with little correlation to the amounts of excitant involved. A "photodynamic sensitizer" is a substance that causes an alteration in the skin or mucous membranes, in general, or to the skin or mucous membrane at the site to which it has been applied, so that when these areas are subsequently exposed to ordinary sunlight or equivalent radiant energy an inflammatory reaction will develop.

(j) *Extremely flammable and flammable substances*—(1) *Extremely flammable substances.* The term "extremely flammable" means any substance that has a flashpoint at or below 20° F., as determined by the method described in § 191.13.

(2) *Flammable substances.* The term "flammable" means any substance that has a flashpoint of above 20° F., to and including 80° F., as determined by the method described in § 191.13.

(k) *Extremely flammable and flammable solids*—(1) *Extremely flammable solids.* A solid substance is "extremely flammable" if it ignites and burns at an ambient temperature of 80° F. or less when subjected to friction, or to percussion, or to an electrical spark.

(2) *Flammable solids.* A solid substance is "flammable" if, when tested by the method described in § 191.14, it ignites and burns with a self-sustained flame at a rate greater than $\frac{1}{10}$ of an inch per second along its major axis.

(l) *Extremely flammable and flammable contents of self-pressurized containers*—(1) *Extremely flammable contents.* Contents of self-pressurized containers are "extremely flammable" if when tested by the method prescribed in § 191.15, flashback (a flame extending back to the dispenser) is obtained at any degree of valve opening and the flashpoint, when tested by the method described in § 191.16, is less than 20° F.

(2) *Flammable contents.* Contents of self-pressurized containers are "flammable" if when tested by the method described in § 191.15 a flame projection exceeding 18 inches is obtained at full valve opening or a flashback (a flame extending back to the dispenser) is obtained at any degree of valve opening.

(m) *Substances that generate pressure.* A substance is hazardous because it "generates pressure through decomposition, heat, or other means" if:

(1) It explodes when subjected to an electrical spark, or to percussion, or to the flame of a burning paraffin candle for 5 seconds or less; or

(2) It expels the closure of its container, or bursts its container, when held at or below 130° F. for 2 days or less; or

(3) It erupts from its opened container at a temperature of 130° F. or less, after having been held in the closed container at 130° F. for 2 days.

(n) *Radioactive substance.* The term "radioactive substance" means a substance which, because of nuclear instability, emits electromagnetic and/or particulate radiation that is capable of producing ions in its passage through matter. Source materials, special nuclear material, and byproduct materials described in section 2(f)(3) of the act are exempt.

(o) *"Accompanying literature".* "Accompanying literature" as used in section 2(n) of the act means any placard, pamphlet, booklet, book, sign, or other written, printed, or graphic matter or visual device which provides directions for use, written or otherwise, and is used in connection with the display, sale, demonstration, or merchandising of a hazardous substance in a container intended or suitable for household use.

(p) *Substantial personal injury or illness.* This term means any illness or injury of a significant nature. It need not be severe or serious. What is excluded by the word "substantial" is a wholly insignificant or negligible injury or illness.

(q) *Proximate result.* A proximate result is one that follows in the course of events without an unforeseeable, intervening, independent cause.

(r) *Reasonably foreseeable handling or use.* This includes the reasonably forseeable accidental handling or use, not only by the purchaser or intended user of the product, but by all others in a household, especially children.

§ 191.2 Human experience with hazardous substances.

Reliable data on human experience with any substance should be taken into account in determining whether an article is a "hazardous substance" within the meaning of the act, and when such data give reliable results different from results with animal data, the human experience takes precedence. Experience may show that an article is more or less toxic, irritant, or corrosive to man than to test animals. Experience may also show other factors that are important in determining the degree of hazard to humans represented by the substance. For example, that radiator antifreeze is likely to be stored in the household or garage and likely to be ingested in significant quantities by some persons. Experience also indicates that a particular substance in liquid form is more likely to be ingested than is the same substance in a paste or a solid and that an aerosol is more likely to get into the eyes and the nasal passages than is a liquid.

§ 191.3 Hazardous mixtures.

For a mixture of substances, the determination of whether such mixture is "hazardous" as defined in section 2(f) of the act should be based on the physical, chemical, and pharmacological characteristics of the mixture. A mixture of substances may therefore be less hazardous or more hazardous than its components because of synergistic or antagonistic reactions. It may not be possible to reach a fully satisfactory decision concerning the toxic, irritant, corrosive, flammable, sensitizing, or pressure-generating properties of a substance from what is known about its components or ingredients. It is prudent to test the mixture itself.

§ 191.4 [Reserved]

§ 191.5 [Reserved]

§ 191.6 Listing of "strong sensitizer" substances.

The Commissioner of Food and Drugs, having considered the frequency of occurrence and the severity of reactions, finds the following substances to have a significant potential for causing hypersensitivity, and therefore they meet the definition for "strong sensitizer" as given in section 2(k) of the act.

(a) Paraphenylenediamine and products containing it.

(b) Powdered orris root and products containing it.

(c) Epoxy resins systems containing in any concentration ethylenediamine, diethylenetriamine, and diglycidyl ethers of molecular weight of less than 200.

(d) Formaldehyde and products containing 1 percent or more of formaldehyde.

(e) Oil of bergamot and products containing 2 percent or more of oil of bergamot.

§ 191.7 Products requiring special labeling under section 3(b) of the act.

(a) Human experience as reported in the scientific literature and to the Poison Control Centers and the National Clearing House for Poison Control Centers establishes that the following substances are hazardous because of their toxicity and the frequency of their involvement in accidental ingestion:

(1) Carbon tetrachloride and mixtures containing it.

(2) Diethylene glycol including mixtures containing 10 percent or more by weight of diethylene glycol.

(3) Ethylene glycol including mixtures containing 10 percent or more by weight of ethylene glycol.

(4) Petroleum distillates such as kerosene, mineral seal oil, naphtha, gasoline, benzine, mineral spirits, paint thinner, Stoddard solvent, and related petroleum distillates and mixtures containing 10 percent or more by weight of such petroleum distillates.

(5) Methyl alcohol including mixtures containing 4 percent or more by weight of methyl alcohol.

(6) Turpentine including gum turpentine, gum spirits of turpentine, steam-distilled wood turpentine, sulfate wood turpentine and, destructively distilled wood turpentine and mixtures containing 10 percent or more by weight of such turpentine.

(b) The Commissioner finds that these substances present special hazards and that the labeling required by section 2(p)(1) of the act is not adequate for the protection of the public health. Under section 3(b) of the act the following specific label statements are deemed necessary to supplement the labeling required by section 2(p)(1) of the act:

(1) *Carbon tetrachloride*. Because of the general systemic poisoning that might result from the ingestion or breathing of vapors of carbon tetrachloride and mixtures containing it, the label shall include the signal word "danger," the additional word "poison," and the skull and crossbones symbol. The statement of hazard shall include "May be fatal if inhaled or swallowed," and "Avoid contact with flame or hot surface."

(2) *Methyl alcohol*. Because of death and blindness that might result from the ingestion of methyl alcohol, the label for this substance (including mixtures) within the percentages specified in paragraph (a)(5) of this section shall include the signal word "danger," the additional word "poison," and the skull and crossbones symbol. The statement of hazard shall include "Vapor harmful," "May be fatal or cause blindness if swallowed," and "Cannot be made nonpoisonous."

(3) *Turpentine and petroleum distillates*. Because these substances (including mixtures) within the percentages specified above, in addition to oral toxicity resulting in systemic poisoning are hazardous because of aspiration into the lungs with resulting chemical pneumonitis, pneumonia, and pulmonary edema, the signal word "danger" is specified, as well as the additional statements "Harmful or fatal if swallowed" and for kerosene and related petroleum distillates "Do not induce vomiting."

(4) *Ethylene glycol and diethylene glycol*. Because these substances (including mixtures) within the percentages specified above are commonly marketed, stored, and used in a manner increasing the possibility of accidental ingestion, the signal word "warning" is specified. In addition, for ethylene glycol the statement "Harmful or fatal if swallowed" and for diethylene glycol the statement "Harmful if swallowed" are required.

TESTING PROCEDURES FOR HAZARDOUS SUBSTANCES

§ 191.10 Method of testing toxic substances.

The method of testing the toxic substances named in § 191.1 (e)(3) and (f)(3) is as follows:

(a) *Acute dermal toxicity (single exposure)*. In the acute exposures the agent is held in contact with the skin by means of a sleeve for periods varying up to 24 hours. The sleeve, made of rubber dam or other impervious material, is so constructed that the ends are reinforced with additional strips and should fit snugly around the trunk of the animal. The ends of the sleeve are tucked, permitting the central portion to "balloon" and furnish a reservoir for the dose. The reservoir must have sufficient capacity to contain the dose without pressure. In the following table are given the dimensions of sleeves and the approximate body surface exposed to the test substance. The sleeves may vary in size to accommodate smaller or larger subjects. In the testing of unctuous materials that adhere readily to the skin, mesh wire screen may be employed instead of the sleeve. The screen is padded and raised approximately 2 centimeters from the exposed skin. In the case of dry powder preparations, the skin and substance are moistened with physiological saline prior to exposure. The sleeve or screen is then slipped over the gauze which holds the dose applied to the skin. In the case of finely divided powders, the measured dose is evenly distributed on cotton gauze, which is then secured to the area of exposure.

DIMENSIONS OF SLEEVES FOR ACUTE DERMAL TOXICITY TEST

(Test Animal Rabbits)

Measurements in centimeters		Range of weight of animals (grams)	Average area of exposure (cm.²)	Average percentage of total body surface
Diameter at ends	Over-all length			
7.0	12.5	2,500-3,500	240	10.7

(b) *Preparation of test animals*. The animals are prepared by clipping the skin of the trunk free of hair. Approximately one-half of the animals are further prepared by making epidermal abrasions every 2 centimeters or 3 centimeters longitudinally over the area of exposure. The abrasions are sufficiently deep to penetrate the stratum corneum (horny layer of the epidermis), but not to disturb the derma—that is, not to obtain bleeding.

(c) *Procedures for testing*. The sleeve is slipped onto the animal, which is then placed in a comfortable but immobilized position in a multiple animal holder. Selected doses of liquids and solutions are introduced under the sleeve. If there is slight leakage from the sleeve, which may occur during the first few hours of exposure, it is collected and reapplied. Dosage levels are adjusted in subsequent exposures (if necessary) to enable a calculation of a dose that would be fatal to 50 percent of the animals. This can be determined from mortality ratios obtained at various doses employed. At the end of 24 hours the sleeves or screens are removed, the volume of unabsorbed material, if any, is measured, and the skin reactions are noted. The subjects are cleaned by thorough wiping, observed for gross symptoms of poisoning, and then observed for 2 weeks.

§ 191.11 Method of testing primary irritant substances.

Primary irritation to the skin is measured by a patch-test technique on the abraded and intact skin of the albino rabbit, clipped free of hair. A minimum of six subjects are used in abraded and intact skin tests. Introduce under a square patch such as surgical gauze measuring 1 inch x 1 inch, two single layers thick, 0.5 milliliter (in case of liquids) or 0.5 gram (in the case of solids and semisolids) of the test substance. Dissolve solids in an appropriate solvent and apply the solution as for liquids. The animals are immobilized with patches secured in place by adhesive tape. The entire trunk of the animal is then wrapped with an impervious material such as rubberized cloth for the 24-hour period of exposure. This material aids in maintaining the test patches in position and retards the evaporation of volatile substances. After 24 hours of exposure, the patches are removed and the resulting reactions are evaluated on the basis of the designated values in the following table:

Evaluation of skin reactions	*Value*[1]
Erythema and eschar formation:	
No erythema	0
Very slight erythema (barely perceptible)	1
Well-defined erythema	2
Moderate to severe erythema	3
Severe erythema (beet redness) to slight eschar formation (injuries in depth)	4
Edema formation:	
No edema	0
Very slight edema (barely perceptible)	1
Slight edema (edges of area well defined by definite raising)	2
Moderate edema (raised approximately 1 millimeter)	3
Severe edema (raised more than 1 millimeter and extending beyond the area of exposure)	4

[1] The "value" recorded for each reading is the average value of the six or more animals subject to the test.

Readings are again made at the end of a total of 72 hours (48 hours after the first reading). An equal number of exposures are made on areas of skin that have been previously abraded. The abrasions are minor incisions through the stratum corneum, but not sufficiently deep to disturb the derma or to produce bleeding. Evaluate the reactions of the abraded skin at 24 hours and 72 hours, as described in this paragraph. Add the values for erythema and Eschar formation at 24 hours and at 72 hours for intact skin to the values on abraded skin at 24 hours and at 72 hours (four values). Similarly, add the values for edema formation at 24 hours and at 72 hours for intact and abraded skin (four values). The total of the eight values is divided by four to give the primary irritation score. Example:

	Exposure time	Exposure unit
Erythema and eschar formation:	*Hours*	*Value*
Intact skin	24	2
Do	72	1
Abraded skin	24	3
Do	72	2
Subtotal		8
Edema formation:		
Intact skin	24	0
Do	72	1
Abraded skin	24	1
Do	72	2
Subtotal		4
Total		12

Primary irritation score is 12÷4=3

§ 191.12 Test for eye irritants.

Six albino rabbits are used for each substance tested. One-tenth of a milliliter of the test substance is instilled in one eye of each rabbit; the other eye, remaining untreated, serves as a control. The treated eyes are not washed following instillation. Ocular reactions are read either with the unaided eye or with the aid of a hand slit lamp. Readings are made at 24 hours, 48 hours, and 72 hours after treatment.

§ 191.13 Tentative method of test for flashpoint of volatile flammable materials by Tagliabue open-cup apparatus.[1] [2]

SCOPE

1. (a) This method describes a test procedure for the determination of open-cup flashpoints of volatile flammable materials having flashpoints below 175° F.

(b) This method, when applied to paints and resin solutions which tend to skin over or which are very viscous, gives less reproducible results than when applied to solvents.

OUTLINE OF METHOD

2. The sample is placed in the cup of a Tag Open Tester, and heated at a slow but constant rate. A small test flame is passed at a uniform rate across the cup at specified intervals. The flashpoint is taken as the lowest temperature at which application of the test flame causes the vapor at the surface of the liquid to flash, that is, ignite but not continue to burn.

APPARATUS

3. The Tag open-cup tester is illustrated in Fig. 1. It consists of the following parts, which must conform to the dimensions shown, and have the additional characteristics as noted:

(a) *Copper bath*, preferably equipped with a constant level overflow so placed as to maintain the bath liquid level ⅛ inch below the rim of the glass cup.

(b) *Thermometer holder*. Support firmly with ringstand and clamp.

(c) *Thermometer*. For flashpoints above 40° F., use the ASTM Tag Closed Tester Thermometer, range of +20 to +230° F., in 1° F. divisions, and conforming to thermometer 9F. of ASTM Standard E 1. For flashpoints from 20° F. to 40° F., use ASTM Tag Closed Tester, Low Range, Thermometer 57F. For flashpoints below 20° F., use ASTM Thermometer 33F. The original Tag Open-Cup (Paper Scale) Thermometer will be a permissible alternate until January 1, 1962. It is calibrated to −20° F.

(d) *Glass test cup*. Glass test cup (Fig. 2), of molded clear glass, annealed, heat-resistant, and free from surface defects.

(e) *Leveling device*. Leveling device or guide, for proper adjustment of the liquid level in the cup (Fig. 3). This shall be made of No. 18-gage polished aluminum, with a projection for adjusting the liquid level when the sample is added to exactly ⅛-inch below the level of the edge or rim of the cup.

(f) "Micro," or small gas burner of suitable dimensions for heating the bath. A screw clamp may be used to help regulate the gas. A small electric heater may be used.

(g) Ignition taper, which is a small straight, blow-pipe type gas burner. The test flame torch prescribed in the method of test for flash and fire points by Cleveland Open Cup (ASTM designation: D 92) is satisfactory.

(h) Alternative methods for maintaining the ignition taper in a fixed horizontal plane above the liquid may be used, as follows:

(1) Guide wire, $\frac{3}{32}$-inch in diameter and 3½ inches in length, with a right-angle bend ½-inch from each end. This wire is placed snugly in holes drilled in the rim of the bath, so that the guide wire is ⅝-inch from the center of the cup and resting on the rim of the cup.

(2) Swivel-type taper holder, such as is used in ASTM METHOD D 92. The height and position of the taper are fixed by adjusting the holder on a suitable ringstand support adjacent to the flash cup.

(i) Draft shield, consisting of two rectangular sheets of noncombustible material, 24 inches x 28 inches, are fastened together along the 28-inch side, preferably by hinges. A triangular sheet, 24 inches x 24 inches x 24 inches is fastened by hinges to one of the lateral sheets (to form a top when shield is open). The interior of the draft shield shall be painted a flat black.

PROCEDURE

4. (a) Place the tester on a solid table free of vibration, in a location free of perceptible draft, and in a dim light.

(b) Run water, brine, or water-glycol solution into the bath to a predetermined level, which will fill the bath to ⅛-inch below the top when the cup is in place. An overflow is permissible for water-level control.

(c) Firmly support the thermometer vertically halfway between the center and edge of the cup on a diameter at right angles to the guide wire, or on a diameter passing through the center of the cup and the pivot of the taper. Place so that the bottom of the bulb is ¼-inch from the inner bottom surface of the cup. If the old Tagliabue thermometer is used, immerse to well cover the mercury bulb, but not the wide body of the thermometer.

(d) Fill the glass cup with the sample liquid to a depth just ⅛-inch below the edge, as determined by the leveling device.

(e) Place the guide wire or swivel device in position, and set the draft shield around the tester so that the sides form right angles with each other and the tester is well toward the back of the shield.

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[1] The Food and Drug Administration has obtained permission from the American Society for Testing Materials, Philadelphia, Pa., to reprint this method in these regulations. The text has been slightly modified, for practical reasons.

[2] ASTM Designation: D 1310–59T, issued 1954; revised 1955, 1956, 1959. This tentative method has been approved by the sponsoring committee and accepted by the American Society for Testing Materials in accordance with established procedures, for use pending adoption as standard. Suggestions for revisions should be addressed to the Society at 1916 Race St., Philadelphia, Pa.

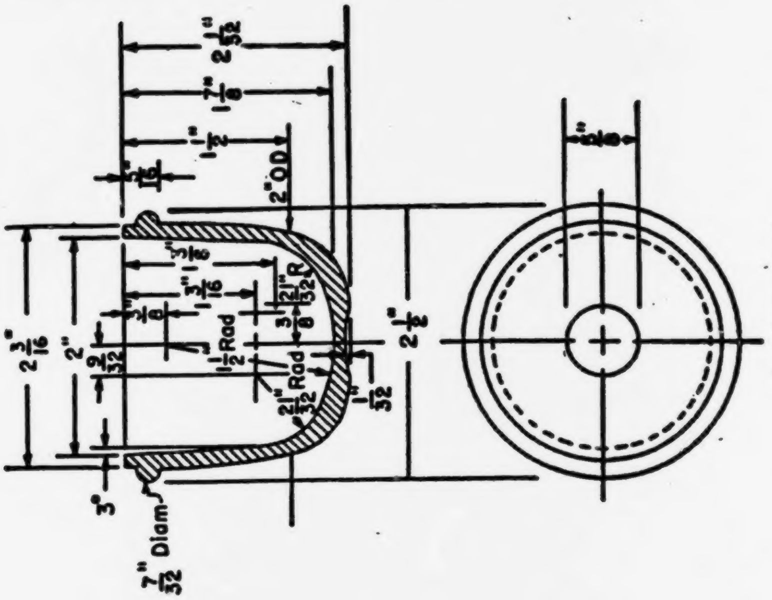
2 21/32"
1 7/8"
1 1/2"
5/16"
2" OD
3/16"
3/16"
3/8"
1 1/2 Rad
21/32 R
3/8
2 1/2"
2 3/16"
2"
9/32
21/32 Rad
1/32
3°
7/32 Diam

FIGURE 3—Glass test cup.

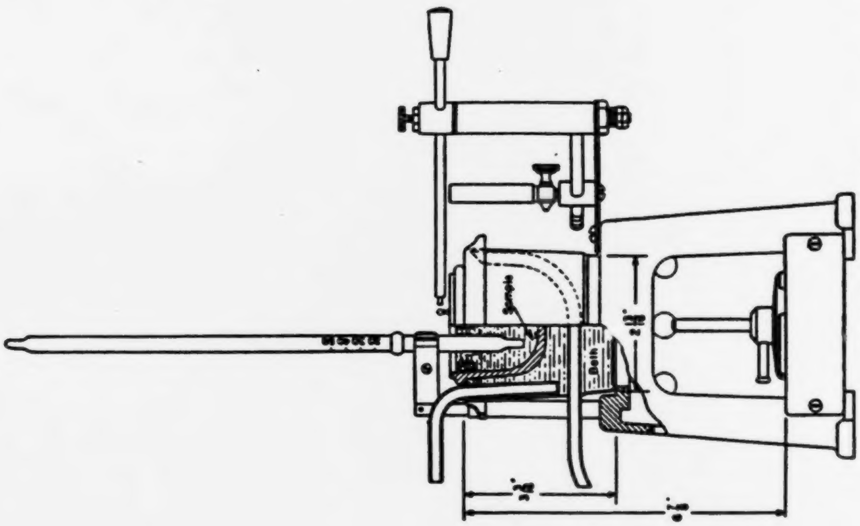
Sample
Bath
2 11/16"
3 1/2"
4 5/8"

FIGURE 1—Tag open-cup flash tester.

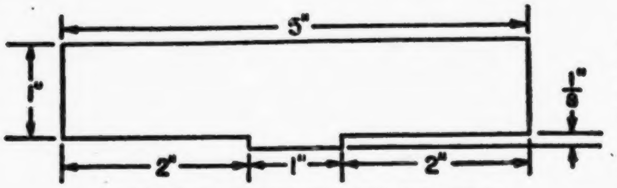

FIGURE 3—*Leveling device for adjusting liquid level in test cup.*

(f) If a guide wire is used, the taper, when passed, should rest lightly on the wire, with the end of the jet burner just clear of the edge of the guide wire. If the swivel-type holder is used, the horizontal and vertical positions of the jet are so adjusted that the jet passes on the circumference of a circle, having a radius of at least 6 inches, across the center of the cup at right angles to the diameter passing through the thermometer, and in a plane ½-inch above the upper edge of the cup. The taper should be kept in the "off" position, at one end or the other of the swing, except when the flame is applied.

(g) Light the ignition flame and adjust it to form a flame of spherical form matching in size the 5/32-inch sphere on the apparatus.

(h) Adjust heater source under bath so that the temperature of the sample increases at a rate of 2 ±0.5° F. per minute. With viscous materials this rate of heating cannot always be obtained.

INITIAL TEST

5. Determine an approximate flashpoint by passing the taper flame across the sample at intervals of 2° F. Each pass must be in one direction only. The time required to pass the ignition flame across the surface of the sample should be 1 second. Remove bubbles from the surface of the sample liquid before starting a determination. Meticulous attention to all details relating to the taper, size of taper flame, and rate of passing the taper is necessary for good results. When determining the flashpoint of viscous liquids and those liquids that tend to form a film of polymer, etc., on the surface, the surface film should be disturbed mechanically each time before the taper flame is passed.

RECORDED TESTS

6. Repeat the procedure by cooling a fresh portion of the sample, the glass cup, the bath solution, and the thermometer at least 20° F. below the approximate flashpoint. Resume heating, and pass the taper flame across the sample at two intervals of 5° F. and then at intervals of 2° F. until the flashpoint occurs.

REPORTING DATA

7. The average of not less than three recorded tests, other than the initial test, shall be used in determining the flashpoint and flammability of the substance.

STANDARDIZATION

8. (a) Make determinations in triplicate on the flashpoint of standard paraxylene and of standard isopropyl alcohol which meet the following specifications:

(i) *Specifications for p-xylene, flashpoint check grade.* p-Xylene shall conform to the following requirements:

Specific gravity: 15.56° C./15.56° C., 0.860 minimum, 0.866 maximum.

Boiling range: 2° C. maximum from start to dry point when tested in accordance with the method of test for distillation of industrial aromatic hydrocarbons (ASTM designation: D 850), or the method of test for distillation range of lacquer solvents and diluents (ASTM designation: D 1078). The range shall include the boiling point of pure p-xylene, which is 138.35° C. (281.03° F.).

Purity: 95 percent minimum, calculated in accordance with the method of test for determination of purity from freezing points of high-purity compounds (ASTM designation: D 1016), from the experimentally determined freezing point, measured by the method of test for measurement of freezing points of high-purity compounds for evaluation of purity (ASTM designation: D 1015).

(ii) *Specifications for isopropanol, flashpoint check grade.* Isopropanol shall conform to the following requirements:

Specific gravity: 0.8175 to 0.8185 at 20° C./20° C. as determined by means of a calibrated pycnometer.

Distillation range: Shall entirely distill within a 1.0° C. range which shall include the temperature 80.4° C. as determined by ASTM method D 1078.

Average these values for each compound. If the difference between the values for these two compounds is less than 15° F. (8.5° C.) or more than 27° F. (16° C.), repeat the determinations or obtain fresh standards.

(b) Calculate a correction factor as follows:

$$X = 92 - A$$
$$Y = 71 - B$$
$$\text{Correction} = \frac{X + Y}{2}.$$

Where:

A = Observed flash of p-xylene, and
B = Observed flash of isopropyl alcohol.

Apply this correction of all determinations. Half units in correction shall be discarded.

PRECISION

9. (a) For hydrocarbon solvents having flashpoints between 60° F. and 110° F., repeatability is ±2° F. and the reproducibility is ±5° F.

(b) If results from two tests differ by more than 10° F., they shall be considered uncertain and should be checked. The calibration procedure provided in this method will cancel out the effect of barometric pressure if calibration and tests are run at the same pressure. Data supporting the precision are given in Appendix III of the 1956 Report of Committee D-1 on Paint, Varnish, Lacquers and Related Products, Proceedings, Am. Soc. Testing Mats., Vol. 56 (1956).

§ 191.14 Method for determining extremely flammable and flammable solids.

(a) *Preparation of sample*—(1) *Granules, powders, and pastes.* Pack the sample into a flat, rectangular metal boat with inner dimensions 6 inches long x 1 inch wide x one-fourth inch deep.

(2) *Rigid and pliable solids.* Measure the dimensions of the sample and support it by means of metal ringstands, clamps, rings, or other suitable devices as needed, so that the major axis is oriented horizontally and the maximum surface is freely exposed to the atmosphere.

(b) *Procedure.* Place the prepared sample in a draft-free area that can be ventilated and cleared after each test. The temperature of the sample at the time of testing shall be between 68° F. and 86° F. Hold a burning paraffin candle whose diameter is at least 1 inch, so that the flame is in contact with the surface of the sample at the end of the major axis for 5 seconds or until the sample ignites, whichever is less. Remove the candle. By means of a stopwatch, determine the time of combustion with self-sustained flame. Do not exceed 60 seconds. Extinguish flame with a CO_2 or similar nondestructive type extinguisher. Measure the dimensions of the burnt area and calculate the rate of burning along the major axis of the sample.

§ 191.15 Method for determining extremely flammable and flammable contents of self-pressurized containers.

(a) *Equipment required.* The test equipment consists of a base 8 inches wide, 2 feet long, marked in 6-inch intervals. A rule 2 feet long and marked in inches is supported horizontally on the side of the base and about 6 inches above it. A paraffin candle 1 inch or more in diameter, and of such height that the top third of the flame is at the height of the horizontal rule, is placed at the zero point in the base.

(b) *Procedure.* The test is conducted in a draft-free area that can be ventilated and cleared after each test. Place the self-pressurized container at a distance of 6 inches from the flame source. Spray for periods of 15 seconds to 20 seconds (one observer noting the extension of the flame and the other operating the container) through the top third of the flame and at a right angle to the flame. The height of the flame should be approximately 2 inches. Take three readings for each test, and average. As a precaution do not spray large quantities in a small, confined space. Free space of previously discharged material.

§ 191.16 Method for determining flashpoint of extremely flammable contents of self-pressurized containers.

The apparatus used is the Tagliabue Open-Cup Flashpoint Apparatus as described in § 191.13. Some means such as dry ice in an open container is used to chill the pressurized container. The container, the flash cup, and the bath solution of the apparatus (brine or glycol may be used) are chilled to a temperature of about 25° F. below zero. The chilled container is punctured to exhaust the propellant. The chilled formulation is transferred to the test apparatus and tested in accordance with the method described in § 191.13.

EXEMPTIONS

§ 191.61 Exemptions for food, drugs, cosmetics, and fuels.

(a) *Food, drugs, and cosmetics.* Substances subject to the Federal Food, Drug, and Cosmetic Act are exempted by section 2(f)(2) of the act; but where a food, drug, or cosmetic offers a substantial risk of injury or illness from any handling or use that is customary or usual it may be regarded as misbranded under the Federal Food, Drug, and Cosmetic Act because its label fails to reveal material facts with respect to consequences that may result from use of the article (21 U.S.C. 321(n)) when its label fails to bear information to alert the householder to this hazard.

(b) *Fuels.* A substance intended to be used as a fuel is exempt from the requirements of the act when in containers that are intended to be or are installed as part of the heating, cooling, or refrigeration system of a house. A portable container used for delivery or temporary or additional storage, and containing a substance that is a hazardous substance as defined in section 2(f) of the act, is not exempt from the labeling prescribed in section 2(p) of the act, even though it contains a fuel to be used in the heating, cooking, or refrigeration system of a house.

§ 191.62 Exemption from full labeling requirements.

(a) Any person who believes a particular hazardous substance in a container intended or suitable for household use should be exempted from full label compliance otherwise applicable under this act, because of the size of the package or because of the minor hazard presented by the substance, or for other good and sufficient reason, may submit to the Commissioner a request for exemption under section 3(c) of the act, presenting facts in support of the view that full compliance is impracticable or is not necessary for the protection of the public health. The Commissioner shall determine on the basis of the facts submitted and all other available information whether the requested exemption is consistent with adequate protection of the public health and safety. If he so finds, he shall detail the exemption granted and the reasons therefor by appropriate order published in the Federal Register.

(b) The Commissioner may, on his own initiative, determine on the basis of facts available to him that a particular hazardous substance in a container intended or suitable for household use should be exempted from full labeling compliance otherwise applicable under this act because of the size of the package, or because of the minor hazard presented by the substance, or for other good and sufficient reason. If he so finds, he shall detail the exemption granted and the reasons therefor by appropriate order in the Federal Register.

§ 191.63 Exemptions for small packages, minor hazards, and special circumstances.

The following exemptions are granted for the labeling of hazardous substances in containers suitable or intended for household use under the provisions of § 191.62(b):

(a) When the sole hazard from a substance in a self-pressurized container is that it generates pressure, the name of the component which contributes the hazard need not be stated.

(b) Common matches, including book matches, wooden matches, and so-called "safety" matches are exempted from the labeling requirements of section 2(p)(1) of the act insofar as they apply to the product being considered hazardous because of being "flammable" or "highly flammable" as defined in § 191.1(k).

(c) Paper items such as newspapers, wrapping papers, toilet and cleansing tissues, and paper writing supplies are exempted from the labeling requirements of section 2(p)(1) of the act insofar as they apply to the products being considered hazardous because of being "flammable" or "extremely flammable" as defined in § 191.1(k).

(d) Thread, string, twine, rope, cord, and similar materials are exempted from the labeling requirements of section 2(p)(1) of the act insofar as they apply to the products being considered hazardous because of being "flammable" or "extremely flammable" as defined in § 191.1(k).

LABELING REQUIREMENTS

§ 191.101 Placement, conspicuousness, contrast.

(a) The signal word, the statement of the principal hazard or hazards, and instructions to read carefully any cautionary information that may be placed elsewhere on the label shall appear together on the main panel of the label. Such information shall be placed together and distinctively apart from other wording or designs. The necessary prominence shall be achieved by placement within the borders of a square or rectangle with or without a borderline, and by use of suitable contrasts with the background achieved by distinctive typography or color, and by both color and typography when needed.

(b) If the product is "highly toxic" as defined in § 191.1(e) the labeling shall also include in conjunction with the word "poison," the skull and crossbones symbol.

(c) The signal word and statement of hazard shall be in capital letters. The size of the signal word (and the word "poison" if required) shall be of a size bearing a reasonable relationship to the other type on the main panel, but shall not be less than 18 point type, and the size of the statement of hazard shall not be less than 12 point type, unless the label space on the container is too small to accommodate such type size. When the size of the label space requires a reduction in type size, the reduction shall be made to a size no smaller than is necessary and in no event to a size smaller than 6 point type.

(d) All the items of label information required by section 2(p)(1) of the act (or by regulations prescribing additional information under section 3(b)) may appear on the main panel; but if they do not, all items except those required by paragraph (a) of this section to appear on the main panel, shall be placed together in a distinctive place with adequate contrast, achieved by typography, color, or layout, in proximity to the directions for use. The type size required for this additional information shall bear a reasonable relationship to the other type used and shall be no smaller than 10 point unless the available label space requires reductions, in which event it shall be reduced no smaller than necessary and in no event smaller than 6 point type unless because of small label space an exemption has been granted under section 3(c) of the act and § 191.63.

§ 191.103 Condensation of label information.

Whenever the statement of the principal hazard or hazards itself provides the precautionary measures to be followed or avoided, a clear statement of the principal hazard will satisfy both the provisions of section 2(p) (E) and (F) of the act. When the statement of precautionary measures in effect provides instruction for first-aid treatment, the statement of the precautionary measures will satisfy both section 2(p) (F) and (G) of the act.

§ 191.105 Labeling requirements for accompanying literature.

When any accompanying literature includes or bears any directions for use (by printed word, picture, design, or combination of such methods), such placard, pamphlet, booklet, book, sign, or other graphic or visual device shall bear all the information required by section 2(p) of the act.

§ 191.106 Substances determined to be "special hazards."

Whenever the Commissioner determines that for a particular hazardous substance in a container intended or suitable for household use, the requirements of section 2(p) of the act are not adequate for the protection of the public health and safety because of some special hazard, he shall by order publish in the Federal Register such reasonable variations or additional label requirements as he finds necessary for the protection of the public health and safety. Such order shall specify a date not less than 90 days after the order is published, unless emergency conditions stated in the order specify an earlier date, after which any container of such hazardous substance intended or suitable for household use which fails to bear a label in accordance with such order shall be deemed to be a misbranded package of a hazardous substance.

§ 191.107 Substances with multiple hazards.

(a) Any article that presents more than one type of hazard (for example, if the article is both "toxic" and "flammable") must be labeled with an affirmative statement of each such hazard; precautionary measures describing the action to be followed or avoided for each such hazard; instructions, when necessary or appropriate, for first-aid treatment of persons suffering from the ill effects that may result from each such hazard; instructions for handling and storage of packages that require special care in handling and storage because of more than one type of hazard presented by the article, as well as the common or usual name (or the chemical name if there is no common or usual name) for each hazardous component present in the article.

(b) Label information referring to the possibility of one hazard may be combined with parallel information concerning any additional hazards presented by the article; *Provided*, That the resulting condensed label statement shall contain all of the information needed for dealing with each type of hazard presented by the article.

§ 191.108 Label comment.

The Commissioner will offer informal comment on any proposed label and accompanying literature involving a hazardous substance if he is furnished with:

(a) Complete labeling or proposed labeling, which may be in draft form.

(b) Complete quantitative formula.

(c) Adequate clinical pharmacological, toxicologicals, physical, and chemical data applicable to the possible hazard of the substance.

(d) Any other information available that would facilitate preparation of a suitable label, such as complaints of injuries resulting from the product's use, or other evidence that would furnish human-experience data.

§ 191.109 Substances named in the Federal Caustic Poison Act.

The Commissioner finds that for those substances covered by the Federal Caustic Poison Act (44 Stat. 1406), the requirement of section 2(p)(1) of the Federal Hazardous Substances Labeling Act are not adequate for the protection of the public health. Labeling for those substances, in the concentrations listed in the Federal Caustic Poison Act, were required to bear the signal word "poison." The Commissioner believes that the lack of the designation "poison" would indicate to the consumer a lesser hazard than heretofore and that such would not be in the interest of the public health. Under the authority granted in section 3(b) of the act, the Commissioner therefore finds that for the following substances, and at the following concentrations, the word "poison" is necessary instead of any signal word.

(a) Hydrochloric acid and any preparation containing free or chemically unneutralized hydrochloric acid (HCl) in a concentration of 10 percent or more.

(b) Sulfuric acid and any preparation containing free or chemically unneutralized sulfuric acid (H_2SO_4) in a concentration of 10 percent or more.

(c) Nitric acid or any preparation containing free or chemically unneutralized nitric acid (HNO_3) in a concentration of 5 percent or more.

(d) Carbolic acid (C_6H_5OH), also known as phenol, and any preparation containing carbolic acid in a concentration of 5 percent or more.

(e) Oxalic acid and any preparation containing free or chemically unneutralized oxalic acid ($H_2C_2O_4$) in a concentration of 10 percent or more.

(f) Any salt of oxalic acid and any preparation containing any such salt in a concentration of 10 percent or more.

(g) Acetic acid or any preparation containing free or chemically unneutralized acetic acid ($HC_2H_3O_2$) in a concentration of 20 percent or more.

(h) Hypochlorous acid, either free or combined, and any preparation containing the same in a concentration that will yield 10 percent or more by weight of available chlorine.

(i) Potassium hydroxide and any preparation containing free or chemically unneutralized potassium hydroxide (KOH), including caustic potash and vienna paste (vienna caustic), in a concentration of 10 percent or more.

(j) Sodium hydroxide and any preparation containing free or chemically unneutralized sodium hydroxide ($NaOH$), including caustic soda and lye in a concentration of 10 percent or more.

(k) Silver nitrate, sometimes known as lunar caustic, and any preparation containing silver nitrate ($AgNO_3$) in a concentration of 5 percent or more.

(l) Ammonia water and any preparation containing free or chemically uncombined ammonia (NH_3), including ammonium hydroxide and "hartshorn," in a concentration of 5 percent or more.

PROCEDURAL REGULATIONS

§ 191.201 Procedure for the issuance, amendment, or repeal of regulations declaring particular substances to be hazardous substances.

(a) The Commissioner may, upon his own initiative or upon the petition of any interested person, showing reasonable grounds therefor, propose the issuance, amendment, or repeal of any regulation provided for in section 3(a) of the act, declaring particular substances to be hazardous substances. The proposal shall be published in the FEDERAL REGISTER, with an invitation for written comments. As soon as practicable after the comments have been received, the Commissioner shall by order act upon the proposal to declare the substance to be a hazardous substance for purposes of the act, or to amend or repeal any regulation previously issued.

(b) Within 30 days after publication of such order, any person who will be adversely affected thereby, if placed in effect, may file objections and a request for a public hearing. The objections shall not be accepted for filing if they fail to establish that the objector will be adversely affected by the regulation, if the objections do not specify with particularity the provisions of the regulation to which objection is taken, or if the objections do not state reasonable grounds. Reasonable grounds are grounds from which it is reasonable to conclude that facts can be established by reliable evidence at the hearing which will call for changing the provisions specified in the objections. Whenever legally valid objections have been filed, a public hearing on the objections will be held.

(c) As soon as practicable after the time for filing objections has expired, the Commissioner shall publish a notice in the FEDERAL REGISTER specifying the parts of the order that have been stayed by proper objections, or, if no objections have been filed, stating that fact.

(d) The procedure at such public hearing shall follow as nearly as practicable procedure described in § 120.14 through § 120.28 of this chapter.

(e) The Assistant General Counsel for Food and Drugs of the Department of Health, Education, and Welfare is hereby designated as the officer upon whom a copy of any petition for judicial review shall be served. Such officer shall be responsible for filing in court the record on which the order of the Commissioner is based in accordance with 28 U.S.C. 2112.

PROHIBITED ACTS AND PENALTIES

§ 191.210 General.

The provisions of these regulations with respect to the doing of any act shall be applicable also to the causing of such act to be done.

§ 191.211 Guaranty.

In case of the giving of a guaranty or undertaking referred to in section 5(b)(2) of the act, each person signing such guaranty or undertaking, or causing it to be signed, shall be considered to have given it. Each person causing a guaranty or undertaking to be false is chargeable with violations of section 4(d) of the act.

§ 191.212 Definition of guaranty; suggested forms.

(a) A guaranty or undertaking referred to in section 5(b)(2) of the act may be:

(1) Limited to a specific shipment or other delivery of an article, in which case it may be a part of or attached to the invoice or bill of sale covering such shipment or delivery; or

(2) General and continuing; in which case, in its application to any shipment or other delivery of an article, it shall be considered to have been given at the date such article was shipped or delivered, or caused to be shipped or delivered, by the person who gives the guaranty or undertaking.

(b) The following are suggested forms of guaranty or undertaking each section 5(b)(2) of the act:

(1) *Limited form for use on invoice or bill of sale.*

....
(Name of person giving the guaranty or undertaking)

hereby guarantees that no article listed herein is in a misbranded package within the meaning of the Federal Hazardous Substances Labeling Act

....
(Signature and post-office address of person giving the guaranty or undertaking)

(2) *General and continuing forms.*

The article comprising each shipment or other delivery hereafter made by ....

....
(Name of person giving the guaranty or undertaking)

to, or on the order of ....

....
(Name and post-office address of person to whom the guaranty or undertaking is given)

is hereby guaranteed, as of the date of such shipment or delivery, to be, on such date, not in a misbranded package within the meaning of the Federal Hazardous Substances Labeling Act.

(Signature and post-office address of person giving the guaranty or undertaking)

(c) The application of a guaranty or undertaking referred to in section 5(b)(2) of the act to any shipment or other delivery of an article shall expire when such article, after shipment or delivery by the person who gave such guaranty or undertaking, becomes misbranded within the meaning of the act.

§ 191.213 Presentation of views under section 7 of the act.

(a) Presentation of views under section 7 of the act shall be private and informal. The views presented shall be confined to matters relevant to the contemplated proceeding. Such views may be presented by letter or in person by the person to whom the notice was given, or by his representative. In case such person holds a guaranty or undertaking referred to in section 5(b)(2) of the act applicable to the article on which such notice was based, such guaranty or undertaking or a verified copy thereof, shall be made a part of such presentation of views.

(b) Upon request, seasonably made, by the person to whom a notice appointing a time and place for the presentation of views under section 7 of the act has been given, or by his representative, such time or place, or both such time and place, may be changed if the request states reasonable grounds therefor. Such request shall be addressed to the office of the Food and Drug Administration that issued the notice.

(c) Any officer or employee of the Food and Drug Administration who is currently authorized to hold hearings under section 305 of the Federal Food, Drug, and Cosmetic Act is hereby authorized to hold hearings under section 7 of the Federal Hazardous Substances Labeling Act.

ADMINISTRATIVE

§ 191.214 Examinations and investigations; samples.

When any officer or employee of the Department collects a sample of a hazardous substance for analysis under the act, the sample shall be designated as an official sample if records or other evidence is obtained by him or any other officer or employee of the Department indicating that the shipment or other lot of the article from which such sample was collected was introduced or delivered for introduction into interstate commerce, or was in or was received in interstate commerce, or was manufactured within a Territory not organized with a legislative body. Only samples so designated by an officer or employee of the Department shall be considered to be official samples.

(a) For the purpose of determining whether or not a sample is collected for analysis, the term "analysis" includes examinations and tests.

(b) The owner of a hazardous substance of which an official sample is collected is the person who owns the shipment or other lot of the article from which the sample is collected.

§ 191.215 Transitional period for relabeling.

The Commissioner recognizes that relabeling will be required to bring products subject to the Federal Hazardous Substances Labeling Act into full compliance. Many such products are marketed in lithographed cans, some of which are pressurized containers. This introduces special problems of relabeling. While most hazardous household substances now carry some warning information, the regulations in this part require that the warnings be amplified, additional information included, and that the warnings and related information be displayed more prominently. In order to meet the February 1, 1962, effective date of the statute, manufacturers and shippers of hazardous substances in containers intended or suitable for household use may develop stick-on labels or other means to provide the required information.

(Sec. 16, 74 Stat. 380; 15 U.S.C. 1261 (note))

Effective date. This order shall be effective February 1, 1962.

Dated: August 8, 1961.

[SEAL] GEORGE P. LARRICK,
Commissioner of Food and Drugs.

[F.R. Doc. 61-7603; Filed, Aug. 11, 1961; 8:46 a.m.]

APPENDIX F

HYDROCARBON GUIDE

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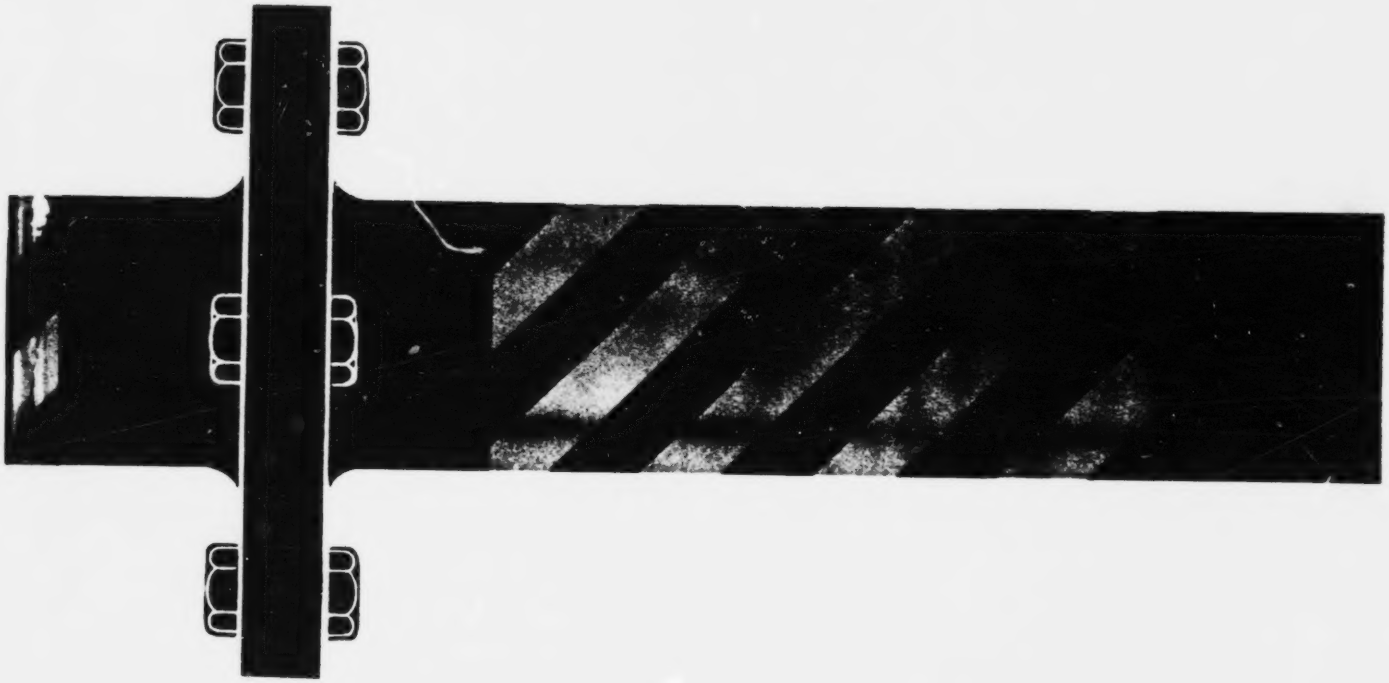
AEROFILL

Hydrocarbon Guide

The Aerosol fillers guide to using Hydrocarbon Propellants



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INTRODUCTION

This handbook has been designed to act as an easy reference book and guide to aerosol fillers using or considering the use of hydrocarbon propellants. It is not intended to replace reference to the relevant authorities and their publications but to highlight their relationship to aerosol filling. The storage and use of hydrocarbons is governed by various Factory Acts, statutes and regulations most of which relate, wholly or in part, to its use in the aerosol industry. In addition the Health and Safety at Work Act places responsibility on the employer and his mangement to operate in a manner that safeguards his employees and the public.

The information in this handbook provides a link between the various statutory regulations, codes of practice and other trade and industrial publications, indicating how these relate to the storage, handling and supply to aerosol filling lines of hydrocarbon propellants. It also covers the safe installation and operation of equipment in the factory and related matters such as finished product storage and waste disposal. The handbook is a guide not a definitive instruction manual since each installation will vary. However, the information given here may help save time, money, effort and risk.

Although the information is biased toward current rules and regulations in the UK and the experience of Aerofill and its customers, it may be assumed that, with minor variations, the contents of this handbook will apply to any installation. Care has been taken to investigate all sources of regulations which may effect hydrocarbon filling installations but all work should be carried out with due reference to the authorities indicated at various points in the text.

The parameters of this handbook have been fixed to deal only with hydrocarbon propellants and related installation operation and usage. No attempt is made to argue the case for hydrocarbon propellants or to deal with formulations which are outside of Aerofill Ltd's field of activity.

D W Thompson.
Hayes, 1977.

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Section 1

PRELIMINARY CONSIDERATIONS

Hydrocarbons are flammable and explosive, however, if handled and used properly they offer the aerosol filler several advantages over other propellants in certain circumstances and formulations. As expected, where any new undertaking is planned using propellants in the form of Liquified Petroleum Gases (L.P.G.) with their hazardous possibilities, there are certain authorities to be consulted. However, the feasibility of installing and using hydrocarbons can be determined by examining certain fundamental requirements.

First	**Is there room for the storage tanks?** L.P.G. storage must be isolated, fig. 1 shows the required separation distances for bulk storage above and below ground. Fig 2. shows some examples of how to apply these separation distances. Storage is dealt with in more detail in the relevant chapters.
Second	**How much propellant will be needed on a daily and weekly basis?** (Hydrocarbon fill in each can) X (the number of cans to be filled) X (the number of days between deliveries and the minimum level to be maintained in the tank.)
Third	**Are the factory premises adaptable to hydrocarbon filling?** Space, as indicated by the above, is likely to be a critical factor and other matters are highlighted in the following chapters relating to layout, operation and safe usage.

If these considerations can be satisfied, a deeper study can commence in consultation with the authorities and suppliers.

Figure 1. Separation Distances for Bulk Storage Vessels.

Storage Categories — *Siting Categories – Distance in Metres*

Water Capacity of Individual Storage Vessels in Litres	*Nominal LPG Capacity (Tonnes)*	*From Building/Property Line or Fixed Point of Ignition*		*Between Vessels*	
		(Above Ground)	*(Under Ground)*	*(Above Ground)*	*(Under Ground)*
Up to 450	0–0.2	None	3	None	1.5
Over 450 to 2,250	0.2–1.0	3	3	0.9	1.5
Over 2,250 to 9,000	1–4	7.5	3	0.9	1.5
Over 9,000 to 135,000	4–60	15	3	1.5	1.5
Over 135,000 to 337,500	60–150	23	5	1.5 or ½ sum of diameter of adjacent vessels, whichever is the greater.	1.5
Over 337,500	150–	30	5		

Storage Categories — *Siting Categories – Distance in Feet*

Water Capacity of Individual Storage Vessels in UK Gallons	*Nominal LPG Capacity (Tons)*	*From Building/Property Line or Fixed Point of Ignition*		*Between Vessels*	
		(Above Ground)	*(Under Ground)*	*(Above Ground)*	*(Under Ground)*
Up to 100	0–0.2	None	10	None	5
Over 100 to 500	0.2–1.0	10	10	3	5
Over 500 to 2,000	1–4	25	10	3	5
Over 2,000 to 30,000	4–60	50	10	5	5
Over 30,000 to 75,000	60–150	75	15	5 or ½ sum of diameter of adjacent vessels, whichever is the greater.	5
Over 75,000	150–	100	15		5

Note 1: The maximum total water capacity of all storage vessels in a group must not be greater than three times the water capacity of the largest vessel permitted in any particular siting category. The maximum number of vessels in a group must not exceed six.

2: For underground storage vessels up to 2,250 litres (500 UK gallons) water capacity, the distance from the valve assembly on the manhole cover and the loading/unloading point to the building/property line or any fixed source of ignition must be at least 3m. (10 ft.); for vessels above 2,250 litres (500 UK gallons), this distance must be at least 7.5m. (25 ft.).

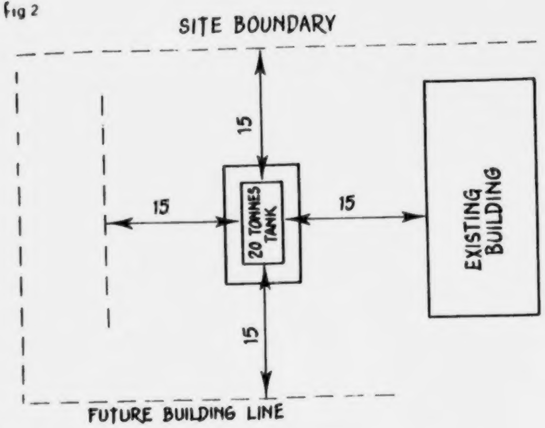
The information given in this chart is based on the Health & Safety Executives' Code of Practice for the Storage of LPG at Fixed Installations. The Nominal Capacities listed are based on the Specific Gravity of Butane 30 at 0.57 S.G. Conversion must be made for Propane or intermediate blends.

Separation Distances for the Storage of Cylinders

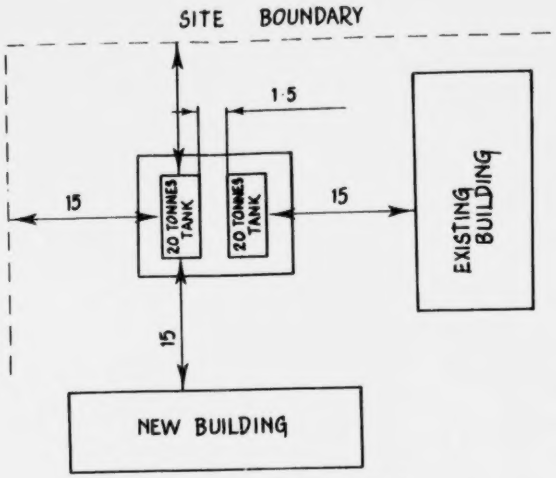
Total Storage LPG Capacity	Min. Separation Distance to Boundary, Building or Fixed Point of Ignition.		
	From Nearest Cylinder (where no radiation wall exists)	From Radiation Wall where provided.	
.50–100 KG	1 metre	Nil	Empty & Full Cylinders must be separated within the compound.
above 100–1,000 KG	3 metres	1 metre	
above 1,000–4,000 KG.	4 metres	1 metre	

Although the Code of Practice for keeping LPG in Cylinders and similar containers lists greater LPG capacities we feel that bulk storage should be given urgent consideration for capacities beyond 4,000 KGs.

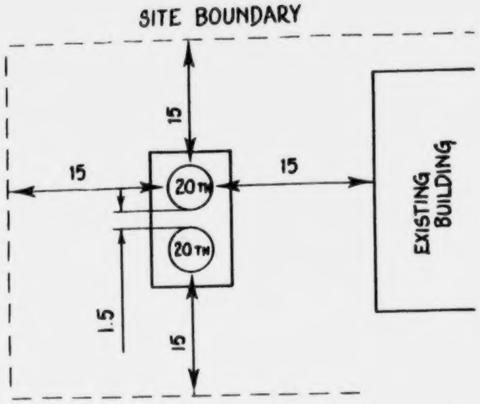
Fig 2


SITE BOUNDARY
15
15
15
15
20 TONNES TANK
EXISTING BUILDING
FUTURE BUILDING LINE

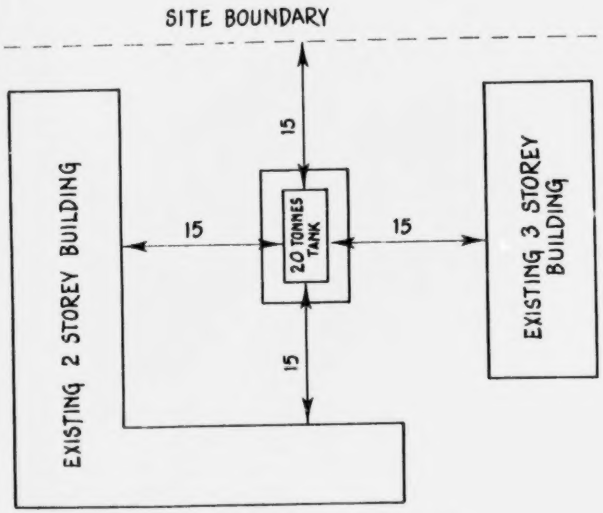
5.1 Layout for 20tn Tank showing extent of separation distance


SITE BOUNDARY
1·5
15
15
15
15
20 TONNES TANK
20 TONNES TANK
EXISTING BUILDING
NEW BUILDING

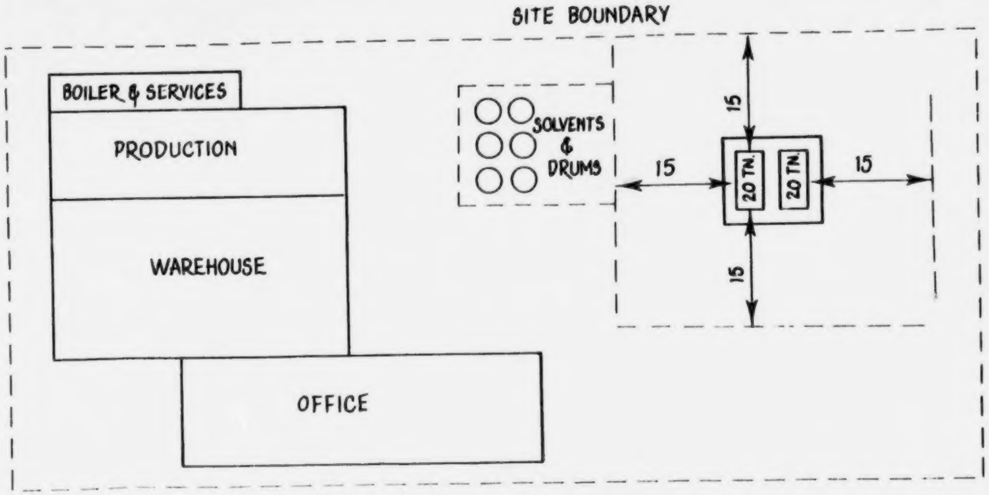
5.2 Additional 20tn Tank installed whilst maintaining separation distance


SITE BOUNDARY
15
15
15
15
1.5
20TN
20TN
EXISTING BUILDING

5.3 In the event that there is insufficient separation distance a 2nd tank may be accommodated with the use of vertical tanks


SITE BOUNDARY
15
15
15
15
20 TONNES TANK
EXISTING 2 STOREY BUILDING
EXISTING 3 STOREY BUILDING

5.4 Although required separation distance has been satsified the tank is enclosed by existing buildings with possibility of future building beyond site boundary giving rise to poor natural ventilation


SITE BOUNDARY
BOILER & SERVICES
PRODUCTION
WAREHOUSE
OFFICE
SOLVENTS & DRUMS
15
15
15
15
20 TN.
20 TN.

5.5 Good layout with tanks isolated with good natural ventilation & room for extension. Required separation from highly flammable liquids is observed whilst boiler house & services are well away from tanks

All dimensions are Metric

Examples of tank installations showing separation distances

Section 2

NOTIFICATION OF AUTHORITIES

Having made your own evaluation of the feasibility, practicality and desirability of using hydrocarbon propellants you cannot proceed without notifying the relevant authorities. Knowledge of your requirements and intentions prior to consulting the authorities will assist and expedite matters. The authorities you are obliged to consult are:

a) **H M Factory Inspectorate**
The Factory Inspectorate are divided into areas and within each area there are Specialist Field Consultant Groups to advise the Local and Area Inspectors. Especially where there are projects calling for special consideration, a consultant may be brought in to advise and assist the company in planning. The Inspector will normally provide considerable assistance and interpret regulations as they apply to your particular site. Matters will be expedited if you have scale layout drawings of your proposal and general data available.

Your local inspector should be known to you with his address on either your Factory Register or your copy of the Abstract of the Factories Act.

b) **Local Planning Authority**
Changes and alterations effecting the factory site may need Planning Permission and in any case the Planning Authority should be informed of the creation of a hazardous area. The work will have to conform to Building Bye-laws and regulations with inspection during progress. Again expediting will be assisted by scale layout drawings.

c) **The Fire Prevention Officer**
The Fire Prevention Officer for your district should be consulted, usually attached to the local fire station but sometimes located at the area headquarters. The Fire Prevention Officer has reporting responsibilities to H M Factory Inspectorate and his co-operation and clearance is necessary to obtain the 'Certificate of Fire Exit' required by the Factories Act. He will provide recommendation on fire alarms, fire points, ventilation and the storage and use of Petroleum substances and Highly Flammable Liquids. He will require information on layout, quantities of propellant to be stored, storage of finished product and intended fire precautions.

d) **Insurance Company**
Advisable, though not obligatory, is early consultation with your insurers concerning risk cover and precautions they would wish to see. Compliance with the Fire Prevention Officer's recommendations or installation by your own choice of a sprinkler system may result in a favourable premium adjustment.

e) Works Safety Committee
Under the Health and Safety at Work Act you are obliged to discuss the project with the Works Safety Committee if you are a company with official Trade Union representation. If Trade Union recognition is not established, it is still advisable to consult your employees especially as you are obliged to instruct and train your employees in working with hazardous materials.

Section 3

HYDROCARBONS AS AEROSOL PROPELLANTS

Hydrocarbons comprise a family of petroleum fractions and in respect of aerosol propellants we are concerned with propane (C_3H_8) and butane (C_4H_{10}) produced generally to British Standard 4250:1975. The hydrocarbon gases are obtained from three sources: natural gas wells, gas issuing from crude oil wells and the 'cracking' of crude oil. In the UK, at present, butane and propane are derived from 'cracking' crude oil, that is breaking it down into its constituent product or fractions.

Both propane and butane are gases at normal ambient temperatures, but are readily liquified by the application of relatively low pressures and stored in bulk vessels at ambient conditions in their liquified state (Liquified Petroleum Gas). The ratio of gas volume to liquid at standard temperature and pressure is approximately 274 and 233 to 1 for propane and butane respectively. This will vary as the gases are blended. The density of the liquid gas is approximately half that of water whilst the density of the vapour gas is approximately 1½ and 2 times that of air.

Liquified Petroleum Gas will burn where its concentration in air lies between the narrow range of approximately 2% to 10% of vapour gas to air by volume. Because the gas vapour is heavier than air it will accumulate at low levels in enclosed and unventilated areas and, since it has a high gas to liquid volume ratio, small quantities in air can produce an appreciably large volume of potentially flammable mixture. These may be ignited by any naked flame or hot surface as well as more subtle ways, such as incendive sparks, unprotected lights, non-flameproofed electrical equipment and static electricity.

Hydrocarbons are therefore hazardous and must be handled and used with care and attention to safety and by competent and properly trained persons, as can be seen from the stress placed in the Codes of Practice and attendant publications indicated in this handbook.

Stenching

As a safety precaution, the hazardous presence of hydrocarbon gas is signalled by a stenching agent (ethyl mercaptan sulphur or dimethyl sulphide) added during the production process. All hydrocarbon gas producing plants make this addition during the process in compliance with BS 4250. Their process is irrevocably committed and the plant therefore contaminated by the stenching agent.

Since the aerosol industry's requirement is small in relation to total hydrocarbon production, non-stenched supply is not commercially viable. It therefore falls to others to offer a de-stenching or sweetening and blending process and to arrange distribution to aerosol fillers in uncontaminated cylinders and bulk tankers. Removal of the stenching agent is normally by absorption into a molecular sieve.

There are certain special mixtures and blends supplied in relatively small quantities for use in high grade cosmetic and toiletry formulations; research and development; and pharmaceutical and medical requirements. These gases are generally the technically superior ISO-butanes in the unstenched condition (imported) with de-stenched propane added to obtain the required vapour pressure. The odour is less noticeable than normal de-stenched butane and propane.

One of the principal drawbacks from a formulation point of view is the odour of the commercially available hydrocarbon propellant even after de-stenching, especially for cosmetic formulations. The source of the crude oil, over which the propellant supplier may have little control, may influence the effectiveness of the de-stenching process.

Grades

To formulate for aerosols using hydrocarbons as a propellant and to cover the wide range of product requirements, it is necessary to use propane and butane, or mixtures of both, to produce the required vapour pressure at 25°C (70°F). It is also necessary, at the same time, to identify the grade or blend of propellant.

The most common grades of hydrocarbon propellant currently in use in the UK are listed below. As will be seen, these are identified by the vapour pressure (psig) at 25°C (70°F), a procedure which is similar to that used in the USA and Canada.

Hydrocarbon propellant 30 = Vapour pressure 2.05 bar (30psig) at 25°C

Hydrocarbon propellant 40 = mix to produce V.P. 2.72 bar (40psig) at 25°C

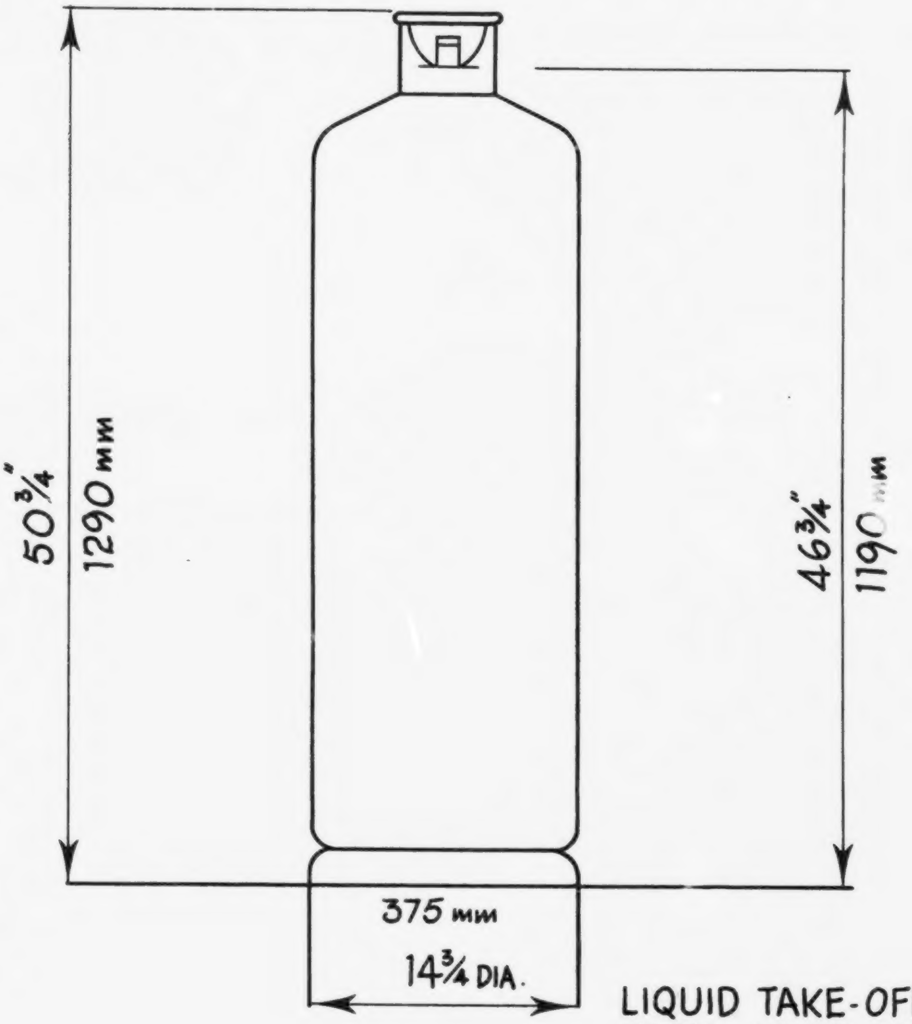
Hydrocarbon propellant 48 = mix to produce V.P. 3.26 bar (48psig) at 25°C

Hydrocarbon propellant 110 = vapour pressure 7.5 bar (110psig) at 25°C

No attempt has been made in this handbook to detail the physical properties of the various hydrocarbons or the specification of each grade. This information may be obtained from the propellant suppliers along with necessary toxicological data.

The foregoing paragraphs relate mainly to UK suppliers of hydrocarbon propellant. Imported sources are available for butane/propane mixtures, but the fact that they are not commonly used is probably a reflection of their price where transport and distribution is a dominant factor. ISO-butane is not available from UK based refining and must therefore be imported.

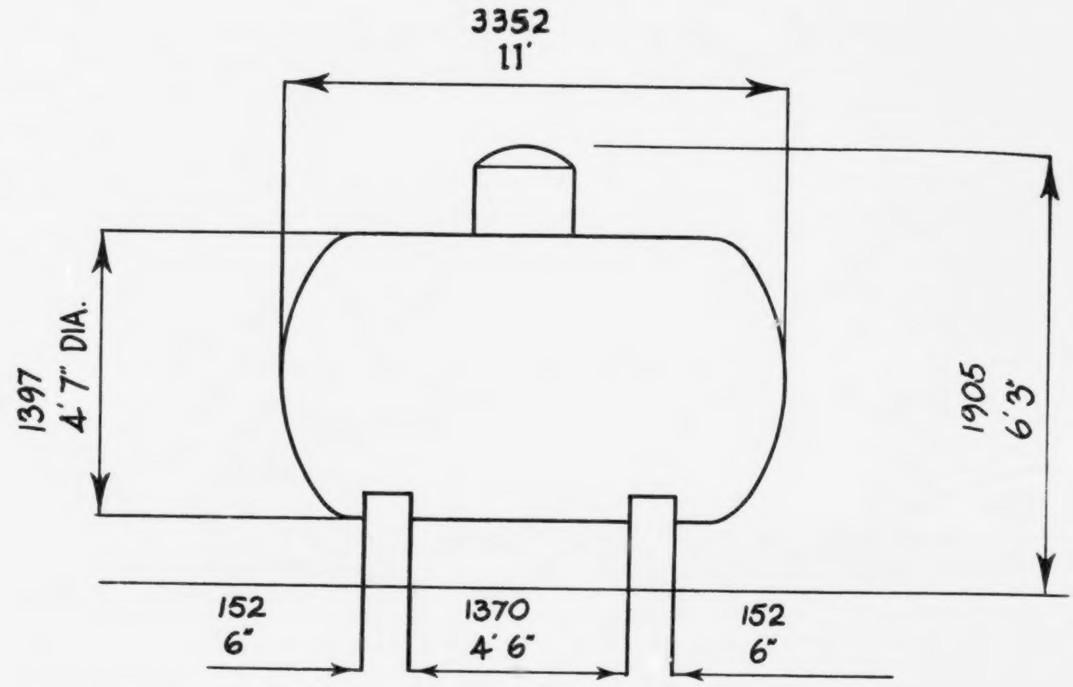
Fig 3


50¾"
1290 mm
46¾"
1190 mm
375 mm
14¾ DIA.

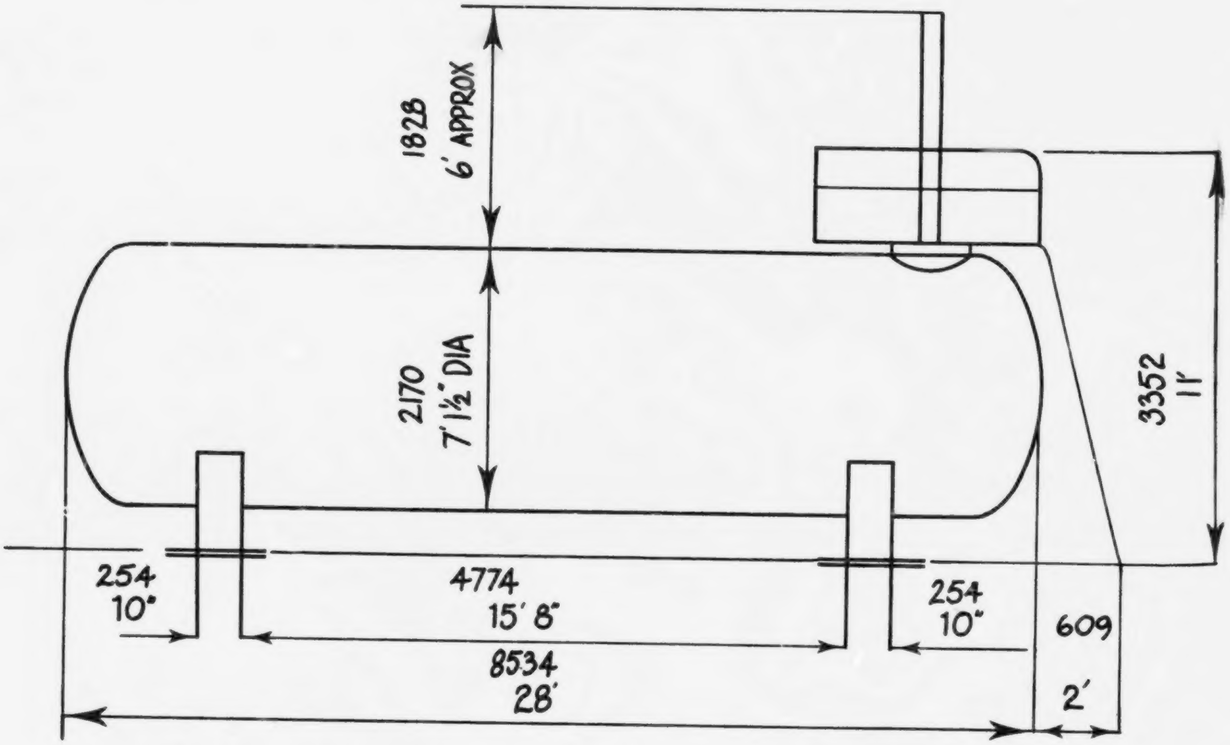
LIQUID TAKE-OFF
TARE 46·75 KGS

TAKEN FROM CALOR LTD. DRG 1435/2

HYDROCARBON CYLINDER
47 KGS CAPACITY


3352
11'
1397
4' 7" DIA.
1905
6' 3"
152
6"
1370
4' 6"
152
6"

2 TONNES HYDROCARBON TANK APPROX 3830 LITRES


1828
6' APPROX
2170
7' 1½" DIA
3352
11'
254
10"
4774
15' 8"
254
10"
609
8534
28'
2'

12 TONNES HYDROCARBON TANK APPROX 23,000 LITRES

HYDROCARBON TANKS
2 & 12 TONNES CAPACITY

Section 4

HYDROCARBON PROPELLANT SUPPLY

Normal butane and propane mixtures to the designations as listed in Section 1 and supplied in the destenched condition are obtainable from Calor Gas Ltd., Calor House, Windsor Road, Slough SL1 2EO, telephone Slough 23824, and their regional offices.

The destenching process is carried out at their works at Millbrook, Southampton, from where U.K. distribution is carried out in cylinders and bulk tankers of up to 15 tonnes capacity.

Calor supply in portable, refillable 47kgs (104lbs) cylinders for laboratory, pilot plant and small scale production use (fig 3) and 2 tonnes and 12 tonnes capacity tanks (fig 4). The cylinders are supplied on a 'free loan' basis, but the 2 and 12 tonnes tanks are supplied on a rental basis, the cost of the installation, civil engineering, pumps and pipework being totally charged to the client to become his property.

Although Calor Gas Ltd. offer a full consultancy service for any installation of hired tanks and for tanks of larger capacity, or installations calling for underground tanks, these projects must be financed by the client.

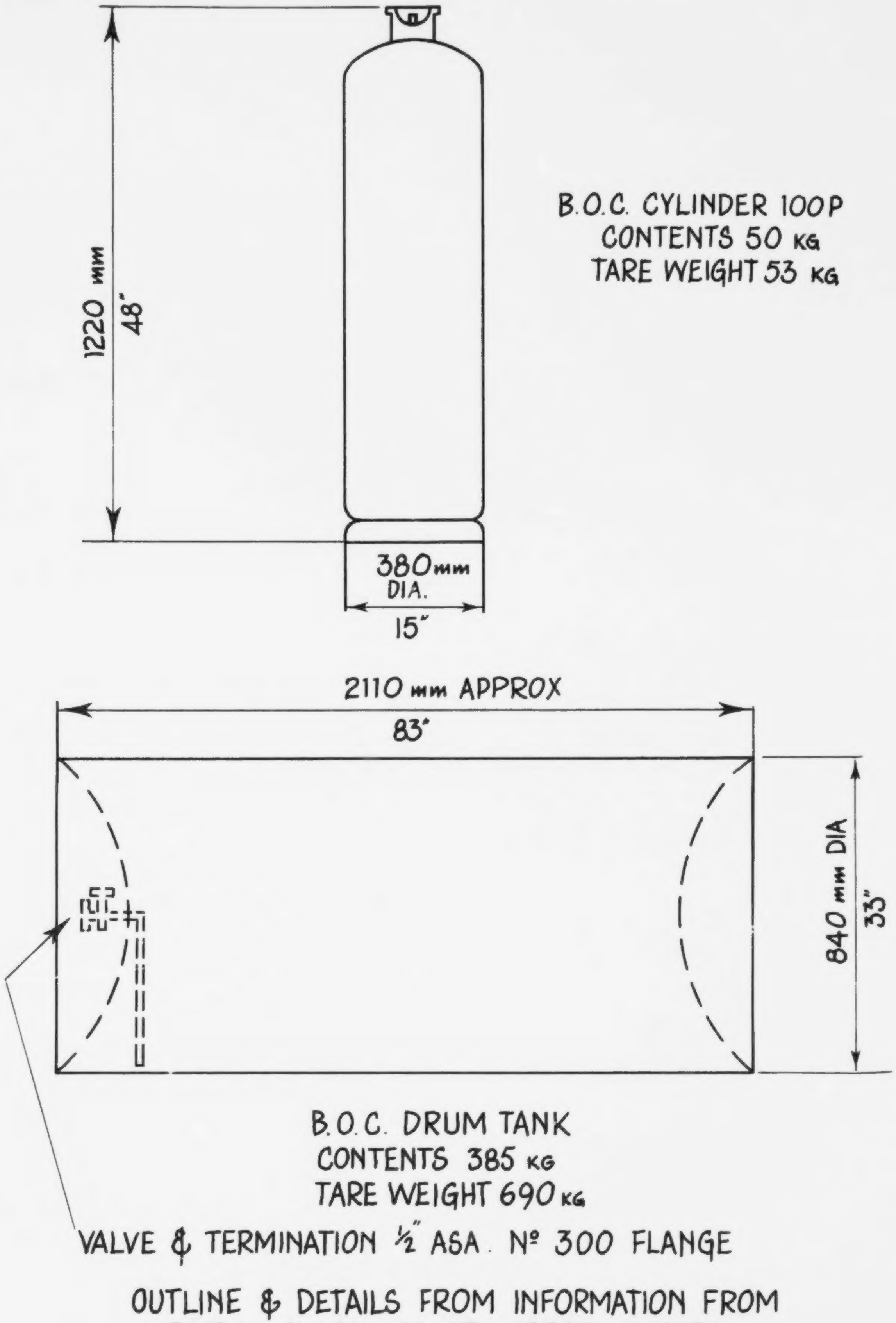
Calor Gas Ltd. maintain their own laboratories at Weybridge, Surrey with a section devoted to aerosol formulations. The company is an active member of British Aerosol Manufacturers Association and participates in its technical activities.

Because of technical and commercial constriction, standards for odour are difficult to establish. The origin of the feedstock will determine the degree to which the propellant may be sweetened and the size and capacity of the molecular sieve filter for a given flow rate. Odour acceptance will depend upon agreement with the supplier and may be monitored by the critical opinion of the chemist in charge or by agreed standards of repeatability based on gas chromotography.

After these standards have been agreed it may well be that the user may wish to install an inline destenching column for further security. However, a flow capacity related to the weight of molecular sieve will need to be established by trial.

Molecular sieves are synthetic alumino silicate crystal powders which range from 1 to 3 microns in diameter and are bound together to form pellets 1.5mm in diameter. The size and position of the metal ions in the crystal controls the effective diameter of the channels that interconnect the millions of tiny cavities in each crystal. This micro "sponge like" form permits the absorption of the molecules of sulphur compounds.

Fig 5


1220 mm
48"
B.O.C. CYLINDER 100P
CONTENTS 50 KG
TARE WEIGHT 53 KG
380 mm
DIA.
15"
2110 mm APPROX
83"
840 mm DIA
33"
B.O.C. DRUM TANK
CONTENTS 385 KG
TARE WEIGHT 690 KG
VALVE & TERMINATION ½" ASA. Nº 300 FLANGE

OUTLINE & DETAILS FROM INFORMATION FROM
BRITISH OXYGEN Cº LTD. SPECIAL GASSES

HYDROCARBON CYLINDERS
50 KG & 385 KG DRUM TANK

The saturated and spent molecular sieve must be regenerated or discarded under controlled conditions to enable the hazardous hydrocarbons to safely disperse and the noxious smell of the sulphur compounds not to cause offence.

Special blends and mixtures of unstenched ISO-butane and destenched propane are supplied by B.O.C. Ltd., Special Gases, Deer Park Road, London SW19 3UF, telephone 01-542 6677.

As stated in Section 3, special grades are supplied for those who require a technically superior specification which is 99% pure, used principally where there is a need for less odour and residual contamination. These grades may be preferred for high class cosmetics and toiletries, research and development and pharmaceutical and medicinal formulations.

Whilst these grades are more expensive and mostly supplied in returnable refillable cylinders of 50kg capacity, they can be supplied in 385kgs refillable drum tanks (fig. 5). Should a requirement demand a bulk installation, B.O.C. Ltd., may be willing to investigate the feasibility.

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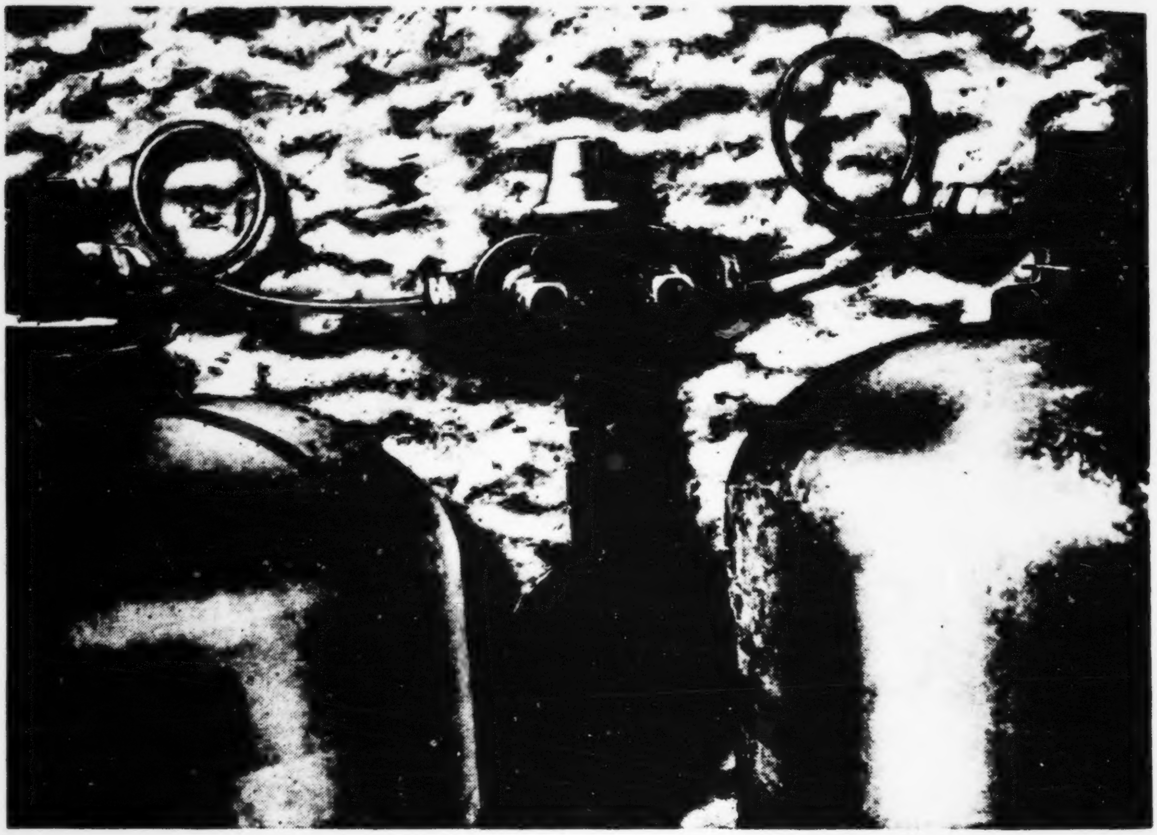

Portable cylinders containing propane located outside a building and connected to a change over valve and pressure reducing valve to supply gas to appliances within the building through fixed piping.

CALOR Gas Aerosol Propellent

15 tonnes Propellant Tanker

Section 5

SMALL SCALE STORAGE OF HYDROCARBON PROPELLANT

Laboratory or pilot line operation and certain small filling operations may not require or accommodate even a small fixed bulk storage installation. In these instances cylinder and drum tank storage may be considered. Refillable, 47kg (104lb) cylinders are the most common, however their limited capacity should be taken into account — at an average fill size four cylinders manifolded together will fill approximately 2,000 aerosols.

For an aerosol filling installation using cylinders, sections of the 'Highly Flammable Liquids and Liquified Petroleum Gases Regulations 1972' and of the Health and Safety Executive's 'Code of Practice for the Keeping of Liquified Petroleum Gas in Cylinders or Similar Containers' will apply. Other requirements may be made by local bye-laws, trade recommendations and good safety sense.

The use of cylinders containing hydrocrabons for aerosol filling can be divided into two separate categories — Cylinders awaiting use and Cylinders in use.

a) Cylinders Awaiting Use

Cylinders awaiting use should be stored in open air in a well ventilated position. The cylinders may be full awaiting use or empty awaiting collection by the supplier. The part of the Health & Safety Executives 'Code of Practice' that refers to storage deals mainly with large quantities of cylinders or cartridges as may be stored in a distribution depot and not an aerosol factory. Part 2 of the code deals with open air storage areas whilst other parts refer to safe handling and procedures. For Aerosol use the quantity of cylinders is not likely to be very large, the total stock required should be fixed and from this the separation distance governing the area can be obtained from fig. 1. Any boundary, building or fixed source of ignition must be beyond these distances which may be extended by H.M. Factory Inspector upon examination of the site and the overall layout of the factory. In certain circumstances a radiation wall may be permitted to overcome the problems of borderline situations.

The area should be identified and secured by a chain link fence at least 2 metres high (6 feet) with two outward opening gates. All cylinders should be stored on their base and in an upright position with protective valve cap in position. Empty and full cylinders should be segregated and identified.

The area shall be free of drains and at least 3 metres (10 feet) from any other cylinders containing oxygen, hydrogen, materials of a corrosive or toxic nature or highly flammable liquids. No combustible materials shall be kept within the area.

Where 385kgs (½ ton) drum tanks are used, a gantry type lifting tackle may be needed to unload the tanks, whilst cradle trolleys are used for moving to point of use. Use chocks to secure the tank.

b) Cylinders In Use

Cylinders in use, except for special laboratory use and under strict conditions should not be used inside a building. They should be set up for use in the open air possibly against an outside wall in a well ventilated place at least 3 metres (10 feet) from any fixed source of ignition, other cylinders and inflammables as stated in **a**).

Cylinders may be manifolded together, in an approved manner with changeover valves and non-return valves in the pipeline from cylinder to manifold to prevent flow from one cylinder to another with the possibility of danger resulting from high pressures.

Manifolded cylinders may be stood on mechanical platform scales as an easy indication of use of hydrocarbon from gross and tare-weights. The cylinders should be secured in the upright position with a supporting cradle or harness chain around the bodies of the cylinders.

The key or shut-off valve knob should not be removed and it is recommended that a notice be fixed around the neck of the cylinder in use: vis

> 'Cylinder in use — shut-off valve open — do not tamper with or close except in an emergency without reference to ....'
> (enter name of suitably qualified and competent person).

The position should be provided with an earth point with earthing strips and provision for earth continuity from cylinder through to the filling equipment.

Empty cylinders and those not connected to the manifold should be returned to the storage area for safe keeping.

The cylinder connection to the manifold may be flexible with self seal coupling. It is preferred that the fixed end be protected by a valve that cannot freeze open in the event of gross leakage. From the manifold to the filling equipment there should be rigid fixed pipework in steel to appropriate British Standard (copper should only be used for vapour lines). **Note:** under no circumstances should plastic air line hose and compression fittings be used.

The pipe route to the filling area should be planned to miss steam pipes, electrical cables and distribution should be as safe and direct as possible — planned in co-operation with H.M. Factory Inspector and the Fire Prevention Officer. Pipes should be identified in compliance with British Standards and direction of flow indicated. All valves should be fire safe and approved for L.P.G. Pressure relief valves, vented safely, should be strategically positioned to prevent any possibility of hydrostatic pressures building up in the pipework with volume changes of gas due to increases in ambient temperatures when plant is idle.

Separate pipelines should be installed for each grade of propellant to be used with proper procedures and description laid down. It is safer to change over pipelines than purge a single pipeline each time a change of propellant is made.

Good safety procedures should be carried out by competent persons properly trained in accordance with the appropriate parts of the relevant codes.

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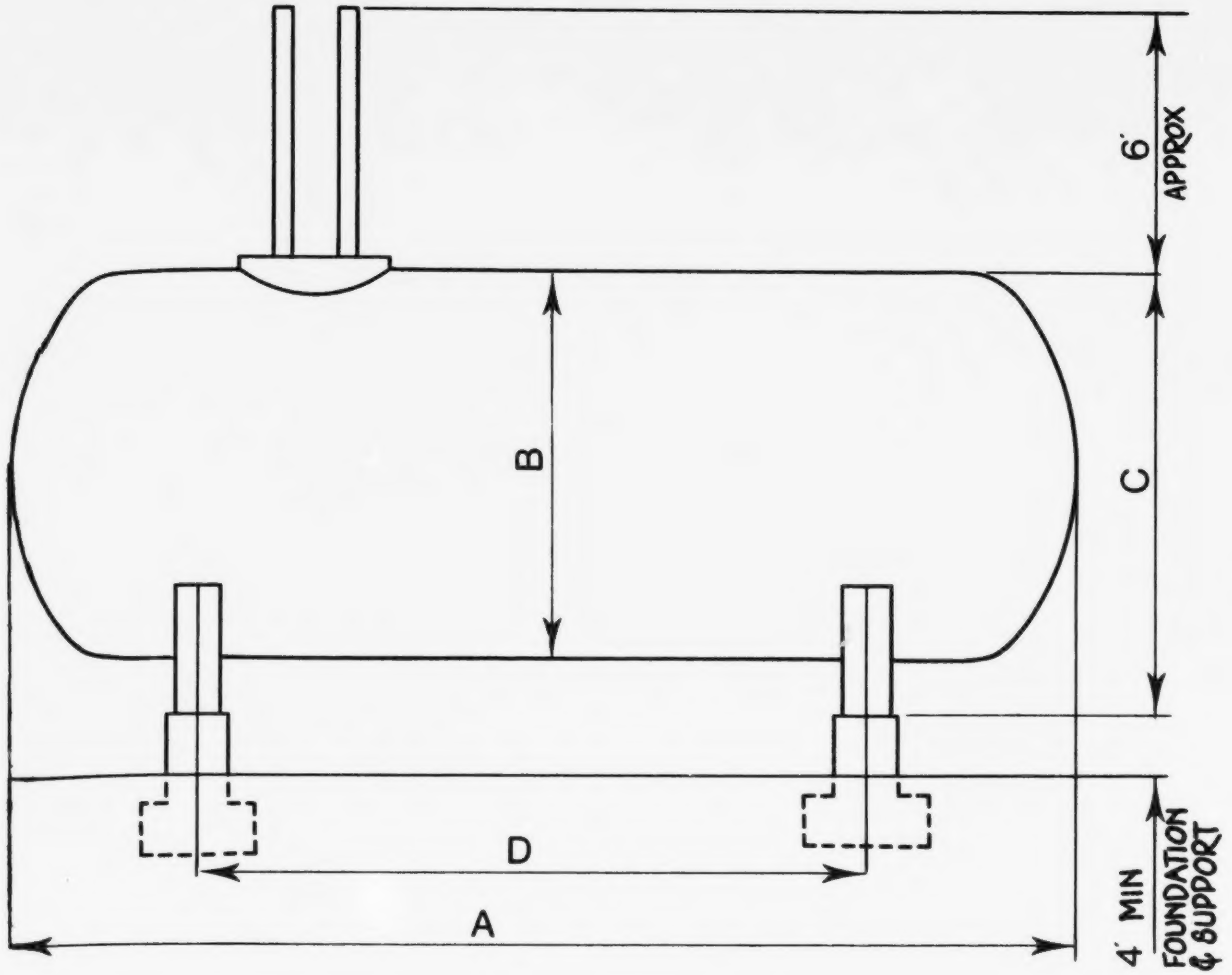
CALOR Gas Aerosol Propellent

15 tonnes Tanker in process of unloading

Fig. 6.


6' APPROX
B
C
D
A
4' MIN
FOUNDATION & SUPPORT

NOMINAL BUTANE CAPACITY	LENGTH A	DIAMETER B	HEIGHT C	CENTRES D
20 TONNES	11m 36'	2.25m 7' 6"	2.6m 8' 6"	8.00m 26'
25 TONNES	12.25m 40'	2.5m 8'	2.25m 9'	8.00m 26'
30 TONNES	7m 23'	3.65m 12'	4.00m 13'	2.5m 8'
50 TONNES	10.25m 34'	3.65m 12'	4.00m 13'	4.25m 14'

ALL DIMENSIONS ARE APPROXIMATE FOR EACH CAPACITY AND MAY VARY WITH MANUFACTURERS DESIGNS

HYDROCARBON TANKS LARGE CAPACITY

Section 6

BULK STORAGE OF HYDROCARBON PROPELLANT

Experience has shown that the conditions for a bulk installation vary widely from site to site, the information given in this section therefore represents acceptable practice and basic guidelines.

The size of any bulk tank installation will depend on seven basic considerations:

a) The maximum daily off-take required.
b) The number of different propellant grades required.
c) The size of tanker delivery and ease of access.
d) The minimum quantity required in the tank to ensure good gravity head for pumping.
e) The time taken to process an order and receive deliveries.
f) Sudden demand and overtime working potential requirements.
g) Allowance for future increases in demand.

When the approximate overall storage capacity required has been determined, dimensions can be obtained from fig. 6 which shows nominal tank sizes. It should be noted that the maximum number of tanks permissable in a group is six.

Tanks used should be designed for L.P.G. storage in compliance with B.S. 1515 : 1965 for butane at a working pressure of 7 bar (100 psig) and propane at 15 bar (220 psig) both at 37.8°C (100°F). In view of the increase in available grades and developments in formulation work, the use throughout of propane rated tanks may be considered a wise investment.

The Code of Practice for the 'Storage of Liquified Petroleum Gas at Fixed Installation' published by the Health and Safety Executive lays down separation distances which will be determined by the size of the tanks chosen. (The data in fig 1 differs from the code only by the inclusion of metric units and the converson of water capacity to nominal L.P.G. capacity. Water capacity refers to the total fill of the tank whilst L.P.G. capacity must allow a headspace of 15% for expansion due to increases in ambient temperature.)

The 'separation distance' is the minimum permitted distance from the tanks to the site boundary, a building or future building line and any fixed source of ignition. To this may be added the distance from the hose connection for tanker unloading, the unloading area being classified as a hazardous area to

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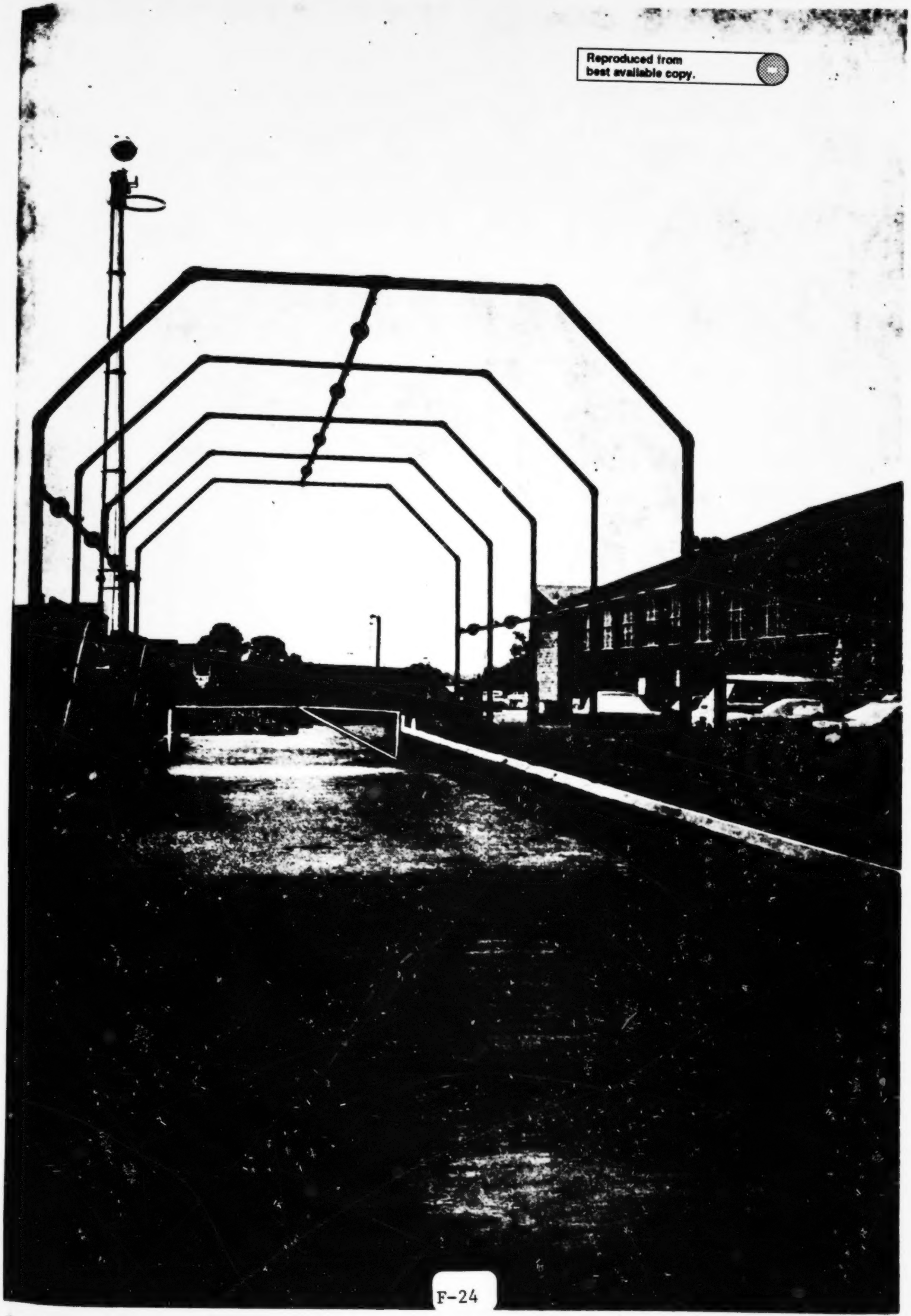
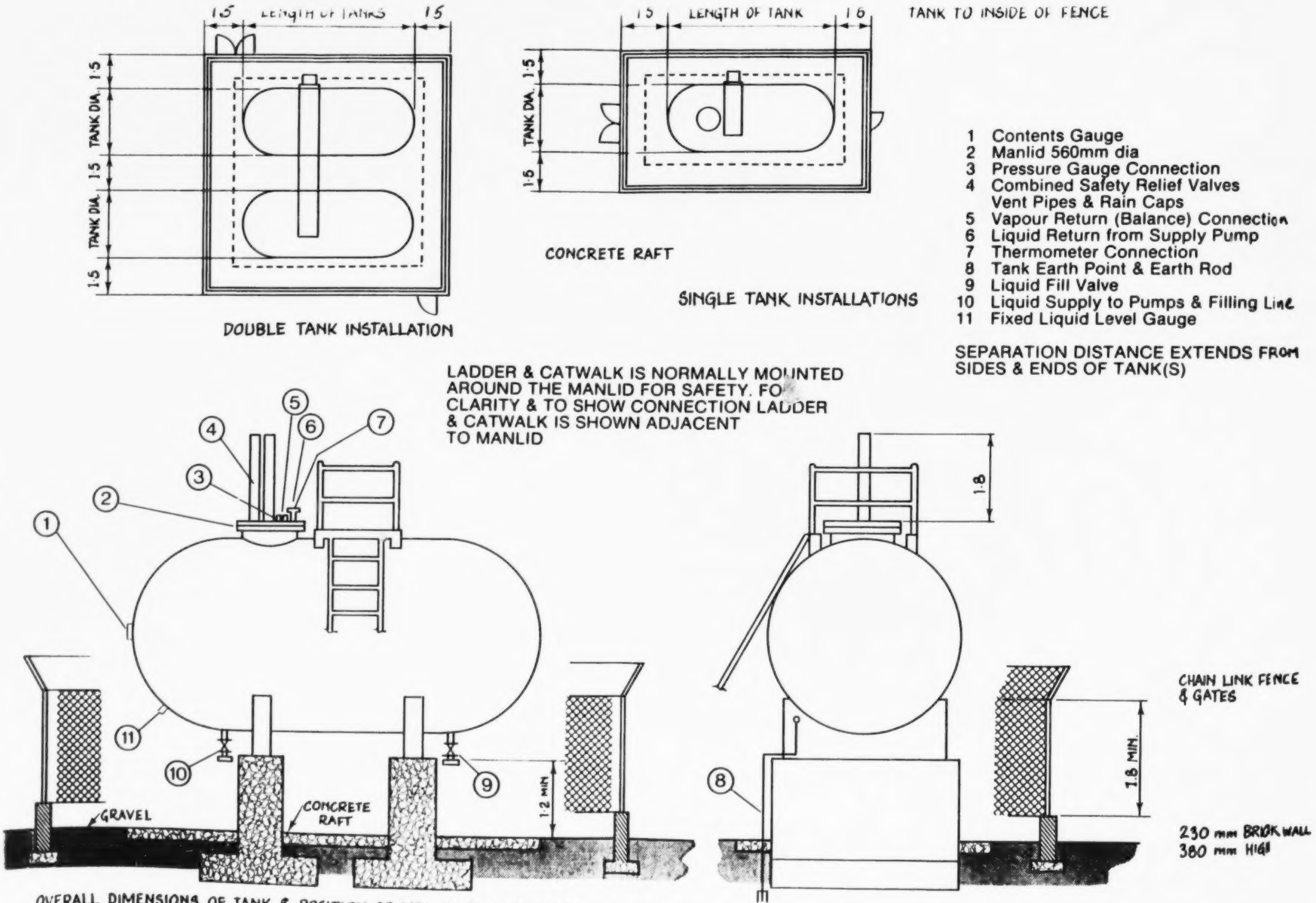


Road tanker vehicle unloading bay, and the manually operated fixed water drenching system over it.


1·5
LENGTH OF TANKS
1·5
1·5
TANK DIA.
1·5
TANK DIA.
1·5
DOUBLE TANK INSTALLATION
1·5
LENGTH OF TANK
1·6
TANK TO INSIDE OF FENCE
1·5
TANK DIA.
1·5
CONCRETE RAFT
SINGLE TANK INSTALLATIONS
1
2
3
4
5
6
7
8
9
10
11
1·8
1·2 MIN
1·8 MIN.
GRAVEL
CONCRETE RAFT
CHAIN LINK FENCE & GATES
230 mm BRICK WALL 380 mm HIGH

1 Contents Gauge
2 Manlid 560mm dia
3 Pressure Gauge Connection
4 Combined Safety Relief Valves Vent Pipes & Rain Caps
5 Vapour Return (Balance) Connection
6 Liquid Return from Supply Pump
7 Thermometer Connection
8 Tank Earth Point & Earth Rod
9 Liquid Fill Valve
10 Liquid Supply to Pumps & Filling Line
11 Fixed Liquid Level Gauge

SEPARATION DISTANCE EXTENDS FROM SIDES & ENDS OF TANK(S)

LADDER & CATWALK IS NORMALLY MOUNTED AROUND THE MANLID FOR SAFETY. FOR CLARITY & TO SHOW CONNECTION LADDER & CATWALK IS SHOWN ADJACENT TO MANLID

OVERALL DIMENSIONS OF TANK & POSITION OF MANLID & CONNECTIONS MAY VARY ACCORDING TO MANUFACTURERS DESIGN

All dimensions are Metric.

SITE OUTLINE & TANK DETAILS
TYPICAL FOR 25/30 TONNES TANKS

Zone One up to 1.5 metres (5 feet) and Zone Two up to 4.6 metres (15 feet). As both Zones demand flameproof electrical equipment, it should be interpreted that the 4.6 metres should be entered into the separation distance calculations, as such it would only extend the layout for tanks under 1 tonne nominal hydrocarbon capacity.

Under certain circumstances the separation distances may be reduced by the inclusion of a radiation wall or by the installation of a fixed water spray system. Dispensations of this nature should be sought from the Factory Inspectorate and the Fire Prevention Officer. Equally, however, distances in excess of those given in fig. 1 may be required if the site lacks good natural ventilation.

Any calculations must also take into account the siting of existing or proposed tanks for solvents or other highly flammable liquids since these should have a separation distance of 15 metres (50 ft) from any hydrocarbon tank farm.

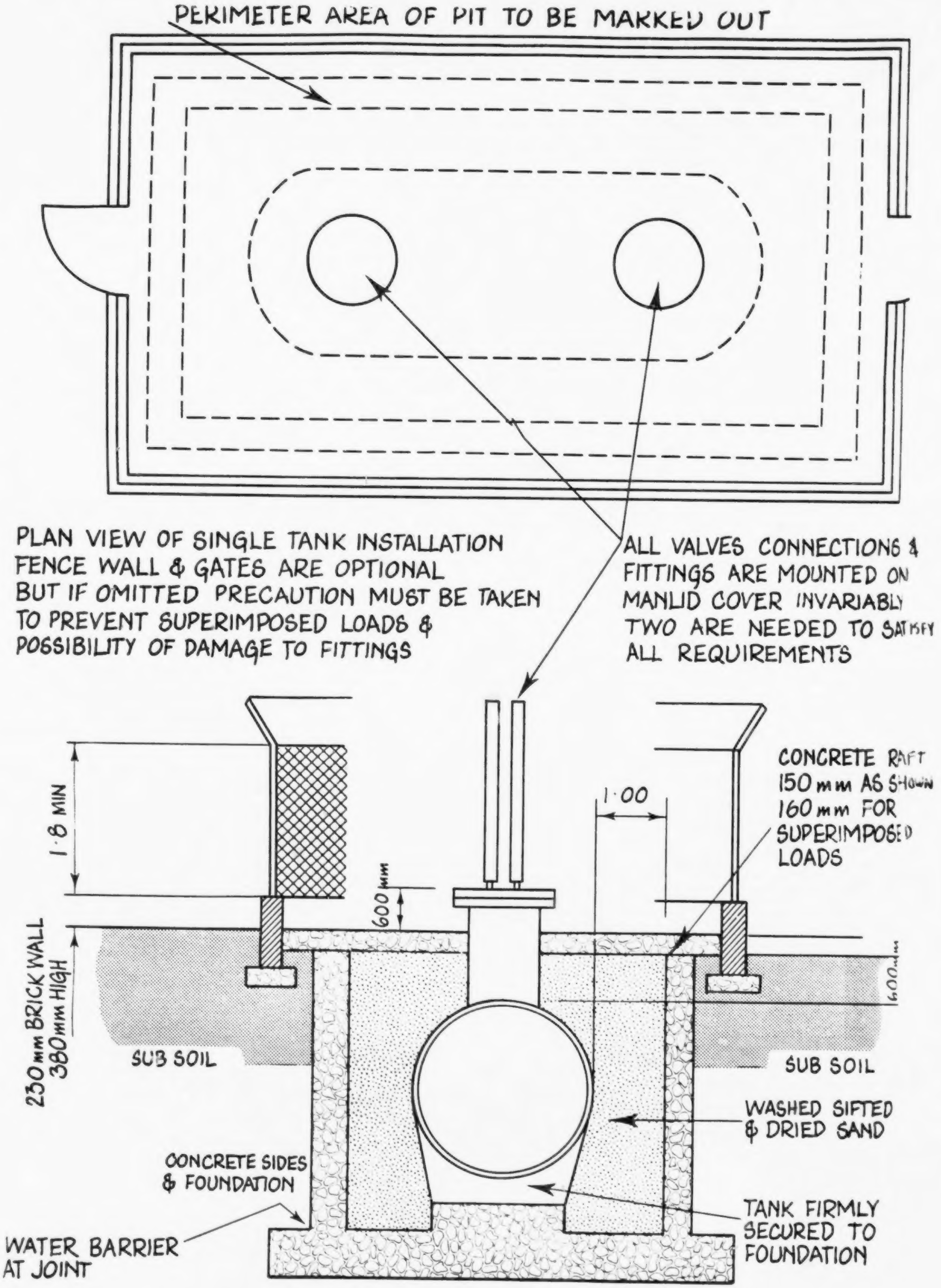
Finally the layout should provide access for tankers of up to 15 tonne capacity using discharge hoses of 9 metres effective length. A turning circle of 18 metres or a reversing space of 8 metres long must be provided for the tankers as they are not permitted to reverse into public highways.

Above Ground Storage

The site for above ground vessels should be as level as possible, free of drains, low lying depressions, pits or water courses. The maximum number of permitted tanks in a group is six and the total combined water capacity should not exceed three times the capacity of the largest permitted vessel in the group. Tank sizes are shown in fig. 6 although dimensions may vary from one manufacturer to another.

There should be a concrete raft sloped to drain any spillage from beneath the tanks to a safe evaporation area within the compound. The area should be protected by a perimeter fence, minimum 2 metres (6 feet) high at a minimum distance of 1.5 metres from the side or ends of the tanks. The fence, in chain link, may be erected on a low continuous wall, maximum height 380 mm (15 inches), to secure the area and prevent trespass or access by unauthorised personnel (bund walls are not permitted). The fence shall have a minimum of two outward opening gates which should be non-self-locking and kept unlocked when the tank farm is in operation — fig. 7.

The footings and plinths for the tanks shall be to appropriate design, strength and fire resistance, which in turn will depend upon local sub-soil conditions and water table. A survey should be conducted to check for buried pipes, drains, culverts and cables which may affect the installation. It is advisable to mount the tanks on plinths as high as possible (minimum 1.25 metres) to produce a good gravity head into the propellant pumps.


PERIMETER AREA OF PIT TO BE MARKED OUT
1·8 MIN
600 mm
1·00
600 mm
230 mm BRICK WALL 380 mm HIGH
CONCRETE RAFT 150 mm AS SHOWN 160 mm FOR SUPERIMPOSED LOADS
SUB SOIL
SUB SOIL
WASHED SIFTED & DRIED SAND
CONCRETE SIDES & FOUNDATION
WATER BARRIER AT JOINT
TANK FIRMLY SECURED TO FOUNDATION

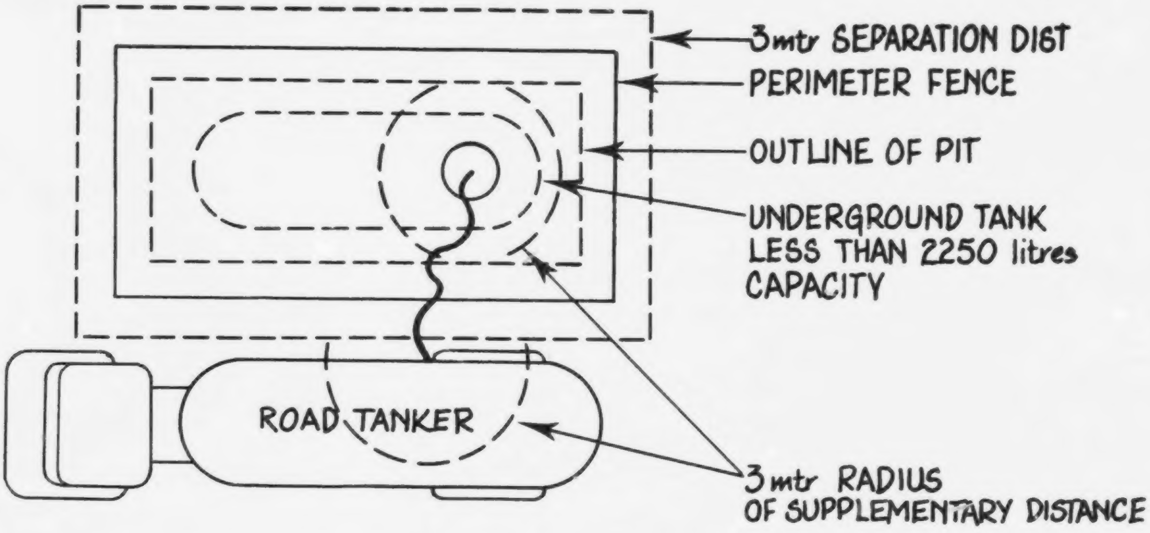
PLAN VIEW OF SINGLE TANK INSTALLATION
FENCE WALL & GATES ARE OPTIONAL
BUT IF OMITTED PRECAUTION MUST BE TAKEN
TO PREVENT SUPERIMPOSED LOADS &
POSSIBILITY OF DAMAGE TO FITTINGS

ALL VALVES CONNECTIONS &
FITTINGS ARE MOUNTED ON
MANLID COVER INVARIABLY
TWO ARE NEEDED TO SATISFY
ALL REQUIREMENTS

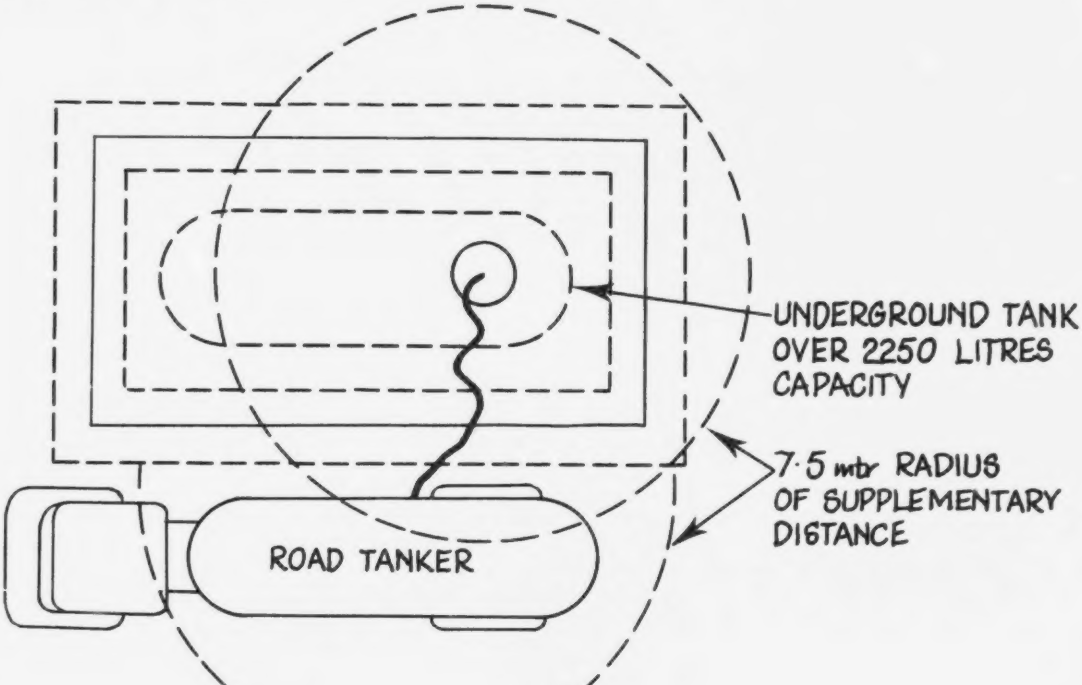
ALL DIMENSIONS
ARE METRIC

SITE LAYOUT & SECTIONS
FOR UNDERGROUND TANKS

Fig 9


3mtr SEPARATION DIST
PERIMETER FENCE
OUTLINE OF PIT
UNDERGROUND TANK LESS THAN 2250 litres CAPACITY
ROAD TANKER
3mtr RADIUS OF SUPPLEMENTARY DISTANCE

EXAMPLE A
TANKS NOT EXCEEDING 2250 LITRES WATER CAPACITY


UNDERGROUND TANK OVER 2250 LITRES CAPACITY
7·5 mtr RADIUS OF SUPPLEMENTARY DISTANCE
ROAD TANKER

Example B

Tanks over 2250 Litres Water Capacity

Underground tanks have a supplementary stipulation on separation distance (see note 2 Fig 4). For a road tanker with delivery hose fixed at tanker the supplementary distance of 3 mtrs (for tanks under 2250 litres capacity) will radiate from the connection of hose & tank point & if made at the manlid will be absorbed in the normal separation distance Example A.

For installations of over 2250 litres capacity the supplementary distance of 7.5 mtrs. will extend beyond the normal separation distance. Example B.

Where loose hoses are carried by a tanker the supplementary distances will radiate from the connections to the tank & the tanker

All dimensions
are metric

Underground tanks
separation layout

Vertical Tanks
Certain savings in space may be achieved by the use of vertical tanks, since separation distances radiate from tank surfaces.

All the requirements for the installation of horizontal tanks will apply, to which must be added the following considerations:

1) A vertical tank installation will be more expensive than an equivalent size horizontal tank.
2) The greater concentration of weight in the tank and its contents will require much stronger foundations.
3) Overall height which includes the vent tubes may invoke planning objections.
4) Height of tank may present Fire Brigade with fire fighting problems.
5) Fixed spray drenching system may be a condition of approval even on a single tank installation.

Underground Storage
Where conditions for above ground tanks cannot be met, it may be possible to install underground tanks where the separation distances are reduced (see fig 8). It should be noted that for vessels up to 2250 litres (500 gallons) water capacity, the distance for the valve on the manlid and the unloading point to boundary buildings, building line or any fixed source of ignition shall be a minimum of 3 metres (10 feet) and for vessels above 2250 litres the distance shall be a minimum of 7.5 metres (25 feet) — fig 9.

The pit excavated for the tank shall be in waterproofed reinforced concrete, to suit sub-soil and water table, large enough to permit 1 metre access between tank and sides for maintenance and inspection. The tank should be secured to the base and should be covered by a minimum of 600 mm of washed and sifted sand used to fill the pit. The tank itself should be properly prepared against corrosion, usually the entire external surface is shotblasted and zinc coated, bitumastic primer and enamel coats are applied and the manways or nozzles wrapped in Thermoglaze or equivalent (cathode protection may be advisable).

The area of the pit above the tank should be finished in concrete to prevent any superimposed load affecting the tank. The perimeters of the pit area shall be permanently marked and identified.

The manways or nozzle should protrude sufficiently above the concrete raft as to allow the lids to be removed for inspection. All relief valves, vent pipes, liquid and vapour connection points and other fittings shall be mounted on the lids and be suitably protected against damage. A security fence should be erected around the perimeter in the same manner as for above ground tanks.

Below ground tanks should be avoided if possible. They are some two or three times more expensive to install than above ground tanks and periodic tests and inspection are also expensive and time consuming, the below ground siting makes pumping difficult and submersible pumps are not recommended. The only advantage of underground tanks is the reduction of the separation distances required to comply with the regulations. It is strongly advised that specialist technical advice be taken concerning the problems of underground tanks, corrosion and pumping.

Pumping

The pumps to supply the propellant to the filling machinery, as liquid at the correct pressure to prevent vaporisation, should be sited within the tank farm but not underneath the tanks. L.P.G. has no lubricating properties and low viscosity. The pumps therefore should be designed and approved for L.P.G. and continously rated. They may be electrically driven multi-stage centrifugal type or air operated reciprocating.

The pumps should be set as low as possible and be provided with a pressure relief to discharge back to the vapour phase of the tank on overload or when the filling lines have little or no demand.

The pumping pressure to the filling lines will depend upon the type of filling machine, the length and diameter of the pipework, the filling offtake and the need to keep the L.P.G. hydraulic in the pipelines to prevent vaporisation on sudden surges. It is advisable to have a standby pump for changeover in case of breakdown, maintenance and repair.

The pumps should be set as low as possible and the tank a minimum of 1.25 metres (4 feet) above on its plinth. Appropriate pipe sizes and a reasonable minimum liquid level should be maintained in the tank to present adequate gravity head to the pumps for operation at correct pressures in all conditions of ambient temperature.

An open-sided shelter in non-combustible materials may be built over the pumps as a weather shield.

Pipework

All pipework shall be steel with flanges, filling valves, etc., to the appropriate British Standards. Pipelengths should be welded or flanged, below 50mm diameter, screwed joints are permitted by the Codes of Practice. Welding to approved standards is preferred as a better earth continuity is possible; in any case P.T.F.E. tape should not be used as a joint sealant.

Sections of pipework should be in manageable lengths, firmly mounted with adequate flexibility for settlement and changes in ambient temperature and routed to the filling area as approved by H.M. Factory Inspectorate and the

Fig. 10

REQUIREMENTS AND EXTENT OF CLASSIFIED AREAS FOR FIXED TANKS

For the UK Zone Areas indicate the degree of risk of fire or explosion from the presence of flammable liquids gases or vapour. In so far as Hydrocarbon for aerosol use the two applicable Zones as set out in BS CP1003 & BS5345 are reprinted below.

Zone 1	An area within which any flammable or explosive substance, whether gas vapour or volatile liquid is stored, handled or processed, and where during normal operations an explosive or ignitable concentration is likely to occur in sufficient quantity to produce a hazard.
Zone 2	An area within which any flammable or explosive substance whether gas vapour or volatile liquid, although processed or stored is so well under conditions of control that the production (or release) of an explosive or ignitable concentration is sufficient quantity to constitute a hazard is only likely under abnormal conditions.

Factor	*Extent of classified area*	*Area classification*
Storage tanks	Within 5ft (1.5m) in all directions from the tank connections or shell	Zone 1
	Up to 5ft (1.5m) above ground level and within the distances set out for pressure storage	Zone 2
Relief valve discharge	Within direct path of discharge	Fixed electrical equipment should not be installed
	Within 5ft (1.5m) in all other directions from point of discharge	Zone 1
	Beyond 5ft (1.5m) but within 15ft (4.6m) in all other directions from point of discharge (10ft for tanks not exceeding 2250 litre cup)	Zone 2
Tank vehicle loading and unloading	Within 5ft (1.5m) in all directions from a point where connections are regularly made or disconnected for product transfer	Zone 1
	Beyond 5ft (1.5m) but within 15ft (4.6m) from point of connection or disconnection (10ft for tanks not exceeding 2250 litre cup)	Zone 2
Pumps, compressors and destench columns	Within 5ft (1.5m) in all directions	Zone 1
a) Outdoors in open air, at or above ground level	Beyond 5ft (1.5m) but within 15ft (4.6m) in all directions (10ft (3m) in the case of storage vessels not exceeding 500 UK gallons (2250 litres) capacity)	Zone 2

Fire Prevention Officer. Valves should be approved for L.P.G. and fire safe. Where relief valves are fitted to prevent build up of hydrostatic pressures, they should vent to a safe place and be protected for inspection and maintenance by locked open shut off valves on either side.

If the use of underground pipes is necessary, ideally they should be in a protective duct, coated and wrapped in suitable protective wrapping material. The duct should be back filled in washed and sieved sand to at least 500 mm (18 inches) below the surface. Cathode protection may be advisable. The duct must be marked and suitable protection provided against superimposed loads or traffic.

All pipes should be painted and marked for direction of flow and identification to British Standard 1710 — 1975. Flexible hoses, where necessary, should be to British Standard 4089 and suitably protected at each end with shut-off valves. If a self-sealing coupling is used, it should be with a valve protecting the fixed end.

Information Note: A flameproof enclosure for electrical equipment is one that will withstand without injury by explosion of flammable gas that may occur within it, under operating and overload conditions within the rating of the equipment and will prevent the emission of any flame that will ignite flammable gas that may be in the atmosphere outside the flameproofed enclosure. Design and application is dealt with in British Standard 229-1957. A guide to selection for Zone 2 areas is available in British Standard 4137 — Fig 10.

Intrinisically safe applies to apparatus and circuits where the electrical energy is so small that any sparking which may occur is incapable of causing ignition, see British Standard CP. 1003 Part 1 and BS 5345.

Note:
British Standard 5345-1976 of which part 1 has been published is intended to update & bring into line with the International Electrotechnical Commission's (IEC) requirements for the selection, installation, & maintenance of Flameproof & Intrinsically Safe electrical equipment & apparatus.
There will be a transition period as Parts 2 to 12 are published during which time certain requirements of other British Standards will still apply, among these are CP1003, BS229 & BS4137.

Safety Procedures
Good safety procedures must be observed in accordance with the Codes of Practice for the tank farms and pipe runs. The whole precincts of the area should be designated non-smoking with suitable notices and restricted to authorised personnel. The tanks should be checked to ensure that there is sufficient space to accept deliveries, and each tank should have its maximum fill capacity clearly marked — this should never be exceeded. Always ensure that the tanker is connected to an earthing rod before discharging tanker contents.

All bulk tankers carry an unloading pump, a meter to gauge the discharge and a flexible unloading hose (9 metres effective length) with standard connections for the bulk tank. Ideally, the tanker parking space should be protected with an overhead sprinkler drenching system, but in any case suitable dry powder fire extinguishers to British Standard 3465 or equivalent should be located adjacent to the unloading area.

A sample of propellant may be taken for approval before discharge, using a sampling unit.

The tanker discharge procedure should be agreed beforehand with the suppliers' technical staff and the management and personnel of the company who will operate the tank farm, staff must be properly trained in all aspects of L.P.G.; safety, fault finding, testing, fire fighting and emergency procedures.

The unloading and factory start up and shut down procedures should be posted at vantage points, numerically itemised in correct and logical sequence.

Assuming reasonable conditions, the total turnround time for a tanker of 10 tonnes capacity is about 2-3 hours. It is usual in the UK to be able to discharge from a tanker without the use of a vapour return line from tank to tanker for pressure balancing.

At all times a competent member of the company's staff and the tanker driver should be in attendance during unloading.

The possibility of fire from an outside source affecting the tank farm and pipeline can be minimised by good plant design and layout, consultation with professional advice, proper training and discipline.

An adequate water supply should be provided for fire fighting and fixed spray system which, in case of fire, will drench the fittings equipment and the tank surfaces at the rate of 10 litre per sq. metre. Small installations may find a 20 mm hose reel adequate. In addition, dry powder portable fire extinguishers to British Standard 3465 should be located at strategic points and clearly marked.

'No Smoking', 'Keep Out' and other signs as considered appropriate should be posted at reasonable intervals around the complex. Signs should also be posted at the approaches beyond the separation distance, preferably with a frontier type barrier on the approach road to keep out unauthorised vehicles especially with petrol engines.

Important Note: L.P.G. fork lift truck and similar vehicles should not have their fuel cylinders refilled with aerosol propellant.

Section 7

SOLVENT STORAGE AND USE

Although this handbook has been written with hydrocarbon in mind, it is felt that it also presents an opportunity to stress the need for correct and safe procedures for the storage and use of solvents, petroleum substances and Highly Flammable Liquids, since the hazards are similar to L.P.G. and irrevocably linked in the formulation and filling of aerosols.

As with L.P.G., petroleum substances and highly flammable liquids are defined by and subjected to the Petroleum Acts and Orders and the Highly Flammable Liquids and Liquefield Petroleum Gases Regulations 1972, as well as local regulations and bye-laws as may be applicable. Furthermore, any proposed installation can only be carried out with the co-operation and acceptance of your local authorities, H.M. Factory Inspectorate and the Fire Prevention Officer.

In the case of any solvent or chemical deemed to be covered by The Petroleum (Consolidation) Act 1928, The Petroleum (Mixtures) Order 1929 and The Petroleum (Inflammable Liquids) Order 1971, a licence to store, mix and use is required from the County Secretariat. Granting of the licence is in the main upon clearance by the Fire Prevention Officer of the safe site layout, handling and use. A schedule of substances is set out in Part 1 of the Order of 1971, but it should be noted that this schedule is not necessarily complete and that substances are covered by the Regulations subject to tests and that have a flash point below 23°C.

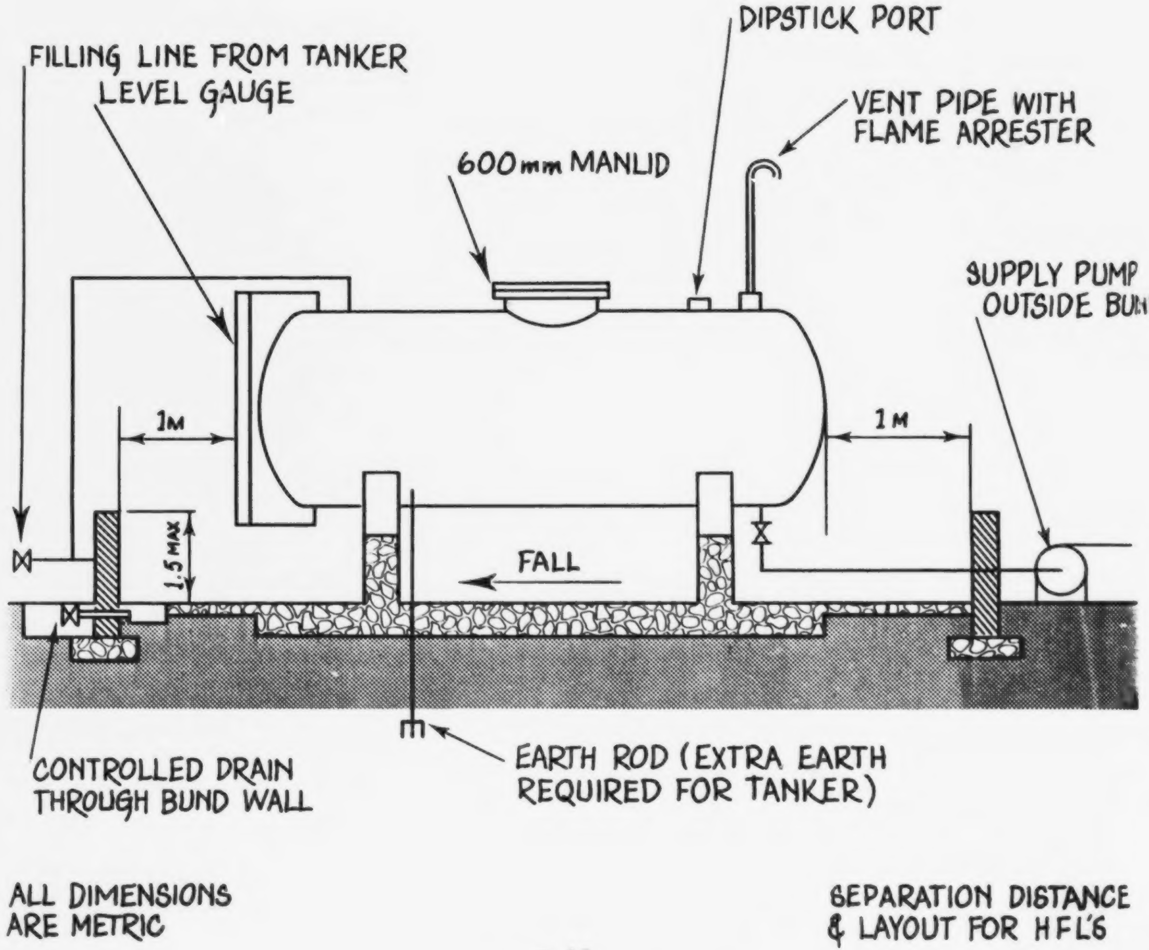
Broadly speaking, Highly Flammable Liquids are identified as having a flash point below 32°C subject to certain tests as laid out in the Highly Flammable Liquids and Liquefied Petroleum Gases Regulations 1972.

Fig 11

Recommended Minimum separation distances for storage tanks

Capacity of tank litres	Total Capacity of tanks in group litres	Distance between tanks	Distance from Bund to building, site boundary or fixed source of ignition
1000	3000	1	1
1000-5000	15000	1	4
5000-33000	100000	1	6
33000-100000	300000	1	8
100000-200000	600000	1.5	10

NOTE Distances indicated are not subject to a code of practice & are given as a minimum recommendation subject to site conditions & opinion of H.M. Factory Inspectorate & Fire Prevention Officer whose advice should be sought.


DIPSTICK PORT
FILLING LINE FROM TANKER
LEVEL GAUGE
VENT PIPE WITH FLAME ARRESTER
600mm MANLID
SUPPLY PUMP OUTSIDE BUND
1M
1M
1.5 MAX
FALL
CONTROLLED DRAIN THROUGH BUND WALL
EARTH ROD (EXTRA EARTH REQUIRED FOR TANKER)

ALL DIMENSIONS ARE METRIC

SEPARATION DISTANCE & LAYOUT FOR HFL'6

Other solvents or chemicals with a flash point of up to 66° C, whilst normally regarded as only flammable, must be regarded as highly flammable if stored at or approaching temperatures near their flash points.

Storage of these liquids in 200 litre drums and similar smaller containers should be in the open or in open sided type structures without walls in a well ventilated position with a bund wall on all sides (maximum height 1.5m) and a ramp or sill for entrance. The net volume of the bunded area should be at least 10% above the capacity of the largest container, and the ground should be impervious to the liquids stored and should be sloped to a spillage drain for evaporation.

In certain circumstances, a radiation wall, of two hour fire resistance, to the height of the highest stack may be included (commensurate with good safety), where required by the layout.

Empty drums must be stored within the area, as they will contain vapour which is potentially hazardous.

Within the bund area, drums should be a minimum of one metre from the bund wall and the compound itself a minimum of four metres from any boundary, building or fixed source of ignition. The compound shall be separated from any bulk tank installation of L.P.G. by a minimum of six metres. These distances may be subject to change dependent upon the geography of the site and consultation with H.M. Factory Inspectorate, the Fire Prevention Officer and your local authorities.

Any forklift truck of similar handling device for use in the area or the mixing room should be spark suppressed or flameproofed to H.M. Factory Inspector's satisfaction.

Certain solvents and chemicals in constant use by the filler may be better contained and more economically purchased in bulk storage tanks. It is usual to employ mild steel tanks tested to 0.76 bar (10psig). These cylindical tanks are generally mounted on plinths and cradles and sized to take the maximum economic delivery based on daily usage and time taken for delivery. The site chosen should have good access for tanker discharge.

Ideally, tanks should be sited above ground, sloped to collect spillage away from the underside of the tanks and surrounded by a bund wall. If more than one tank is bunded, the area shall be able to contain the net volume of 10% above the capacity of the largest container (maximum bund height 1.5m). All pumps and switch gear and valve sets, shall be outside the bund area.

Underground tanks may be used to reduce separation distances but these require special conditions of either vaulted construction or concrete jacket and as a rule are some two to three times more expensive than similar above ground installations.

Fig 11 shows the generally accepted safe distances for above ground tanks. Pipework (suitably marked), into the factory area, should be in accordance with appropriate British Standards and the routing should be decided in consultation with H.M. Factory Inspectorate.

Bulk tanks should not be located inside a building or on roofs.

Mixing

The mixing room or rooms should be totally enclosed and separated from the production and storage areas of the factory by suitable fire resistant walls and doors. The whole area should be flameproofed but dispensation in this regard may be obtained from the H.M. Factory Inspectorate. Certainly the area in the vicinity of the mixing vessels and holding tanks should be considered a Zone 2 area (British Standard BS5345). Mixing and holding vessels should be totally sealed or provided with access lids as small as possible with good tight fit.

Ventilation should be adequate throughout the whole area, firstly to eliminate the concentration of any highly flammable vapour likely to be a fire hazard and secondly to provide a safe fresh air atmosphere for the protection of the health of personnel under the Health & Safety At Work Act (see note concerning chemical data sheets and handling and safety precautions, Sections 9 and 12).

Ventilation rates will be set in co-operation with H.M. Factory Inspectorate, but as a general rule the two requirements of the preceeding paragraph should be followed. As the emphasis is on containing the chemicals in closed containers, mixing, stirring and pumping should be kept to a minimum (heat input increases evaporation). Where vessel lids must be opened for the introduction of solvents and ingredients, ventilation should be from within the vessel to a safe place, so that the velocity over the lid opening shall be at least 46 metres per minute to prevent evaporation to surrounding areas.

The area under the mixing vessels and the general mixing area should be bunded or silled and the whole floor fitted with gutters to drain to an effluent sump for disposal (see Section 10).

The aerosol product filling should be fixed by an area of demarcation dependent upon the type of machinery and size of operation and is dealt with in Section 8.

Section 8

AEROSOL FILLING

There is no single piece of legislation that deals with aerosol filling; in other sections of this handbook we have referred to and listed most of the regulations and laid stress to those of particular reference to hydrocarbon storage, etc. Certain parts of those regulations apply to aerosol filling, the most important being 'The Highly Flammable Liquids and Liquefied Petroleum Gases Regulations 1972', the interpretation of which, coupled with the special considerations of aerosols, should govern the approach to the filling and packaging operations.

From other sections of this handbook it can be readily appreciated that, whatever the size of the filling operation, we must:

1. Understand the nature of the hazard of hydrocarbon and highly flammable liquids.
2. Consider the hydrocarbon propellant filler as a Zone 1 area.
3. Consider the surrounding area as a Zone 2 area.
4. Contain the propellant filling operation in as small an area as possible commensurate with the rate and needs of production and ventilation.
5. Ventilate to remove any hazardous and harmful vapour.
6. Ensure a safe routing of propellant pipework through the factory.
7. Evaluate, install and maintain a safe operating procedure at all times and for all personnel.

An exact specification for filling cannot be laid down, for it will alter with the changing circumstances and machinery at each factory and to some extent upon the requirements of the Factory Inspector and his Field Consultants in your region. It is therefore unreasonable to expect H.M. Factory Inspectorate to have a unified and detailed policy for the whole country. The British Aerosol Manufactuers Association have published a 'Guide to Safety in Aerosol Manufacture' covering generally aerosol filling using all types of propellants. We subscribe to its objectives and agree with its recommendations, good counsel ideas and procedures and commend them to the reader. We do not wish to repeat them in this section, but to concentrate on the seven points mentioned earlier, and to show how we feel the line layout should be tackled, and accept that in the process repetition in part at least will be inevitable.

1. Understand the nature of the hazard of hydrocarbon and HFL's

In all the preceding sections, we have stressed the nature and the hazards of hydrocarbons and highly flammable liquids (HFL's) and have quoted and made reference to Codes of Practice and relevant regulations and recommendations. Whilst reiterating the seriousness of the hazard, use of hydrocarbons and HFL's may be safely carried out with containment and adequate ventilation as the first line of defence.

2. Consider the hydrocarbon propellant filler as a Zone 1 area
Dangerous area designations are shown in Figure 10 and are abstracted from the British Standard Code of Practice CP1003 Parts 1, 2 and 3, 1967 and BS5345. From these designations and with the inevitable release of a small quantity of hydrocarbon when the aerosol disconnects from the filling adaptor, we must accept that the propellant filler or the total machine (if the propellant filler is an integral part of the complete aerosol filling machine), must be considered a Zone 1 area and that electrical equipment must be flameproofed or intrinsically safe to the appropriate standard.

3. Consider the surrounding area a Zone 2 area
The Code of Practice CP1003 states that in an indoor situation a Zone 1 area must be separated to ensure that there is no uncontrolled flow of flammable liquid gas or vapour from that area to a Zone 2 area or a safe area. We must accept that the area adjacent to a Zone 1 area must always be considered Zone 2 by virtue of the aerosol conveyor inlet and outlet openings in the wall of the Zone 1 area. Where concentrates are filled separately from propellant and where those concentrates contain HFL's, that area may be Zone 2 provided proper controls are exercised — fig. 12.

4. Contain the propellant filling operation in as small an area as possible commensurate with the rate and needs of production and ventilation.
Dependent upon the size of the filling operation, factory space available, throughput of cans, the type of machinery used, the formulation and valves to be used; the propellant filling area or booth may vary in size and layout. The following examples are all based on indoor installations:

a) **Manual filling operation (Dual Pak *equipment)** — since the propellant filling is integral with the complete equipment, the whole should be housed in a Zone 1 enclosure of sufficient floor area to permit good operation, access to the equipment for adjustment, space for concentrate header tank and space to offset possible claustrophobic effects and to provide operator comfort, see fig. 12-1. Can and valve space should be limited to reasonable quantities, say 2/3 hour supply; and combustible outer packing materials should be removed from the area at regular intervals, although passage through the doors or door opening should be kept to a minimum.

b) **Rotary index type filling (Star Pak *machinery)** — the same considerations should be taken as in 4a), especially where the propellant filling is integral with the complete machine, fig. 12-2, but it may be considerably larger in area if two back to back machines are employed. A preferred alternative is to segregate the propellant filling by the use of a selfcontained rotary index unit housed in its own Zone 1 enclosed area, fig. 12-3, whilst the concentrate filling and crimping operations are carried out on the main rotary index machine housed in a Zone 2 area under flameproofed conditions; back to back can also be accommodated in this fashion. The advantage of this alternative is that the main hazard of hydrocarbon is isolated in an area without the need for operators.

Note: the extent of the Zone 2 concentrate filling area may be reduced if non-flammable concentrates are used.

EXAMPLES OF FILLING AREAS

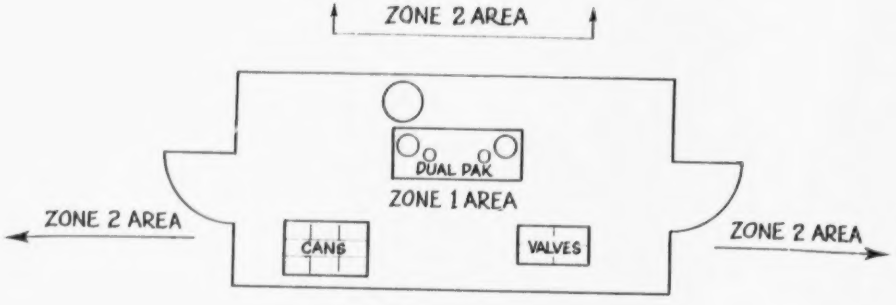

ZONE 2 AREA
DUAL PAK
ZONE 1 AREA
ZONE 2 AREA
CANS
VALVES
ZONE 2 AREA

Fig 12-1 Hand filling
Complete filling operation enclosed in Zone 1 Area with local extraction at filling head level & main extraction at floor level inlets (min 4) so positioned as to prevent any vapour reaching Zone 2 area which will extend (or be enclosed) to a distance as required by H.M. Factory Inspector.

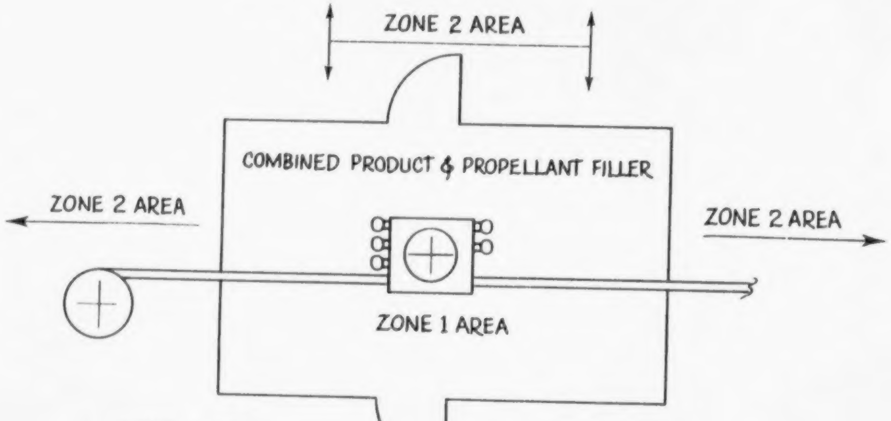

ZONE 2 AREA
COMBINED PRODUCT & PROPELLANT FILLER
ZONE 2 AREA
ZONE 2 AREA
ZONE 1 AREA

Fig 12.2 Medium speed filling
Complete filling operation enclosed in Zone 1 Area with same considerations as Fig 12-1
Unscrambler may be located in Zone 2 Area if all electrical equipment is flameproofed.

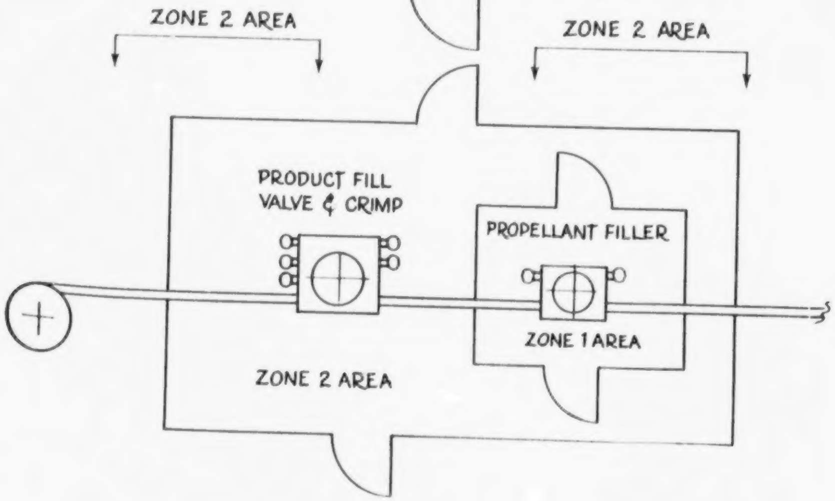

ZONE 2 AREA
ZONE 2 AREA
PRODUCT FILL VALVE & CRIMP
PROPELLANT FILLER
ZONE 1 AREA
ZONE 2 AREA

Fig 12-3. Medium speed filling
Whilst product filling, valving, crimping is carried out in a Zone 2 area the Hydrocarbon is separately filled on a smaller machine in a self contained Zone 1 Area. The product filling area will require its own **Separate** ventilation if Highly Flammable liquids are used.

NOTE: In all cases separate ventilation may be required for operator comfort & health protection

Drawings are Schematic & not to scale

EXAMPLES OF FILLING AREAS

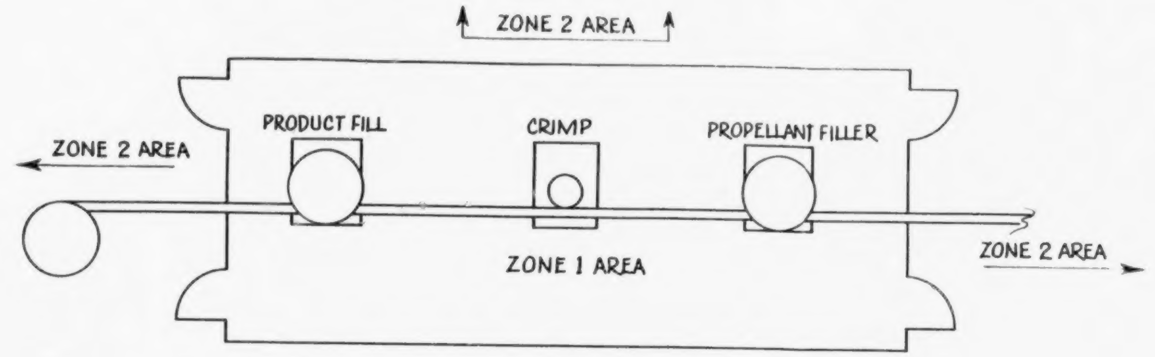

ZONE 2 AREA
PRODUCT FILL
CRIMP
PROPELLANT FILLER
ZONE 2 AREA
ZONE 1 AREA
ZONE 2 AREA

Fig 13-1 Rotary Machine Filling
All filling operations housed in Zone 1 Area propellant filler requires special ventilation with total Area. Since area tends to be large this method is not recommended. Examples 13-2 or 13-3 are preferred.

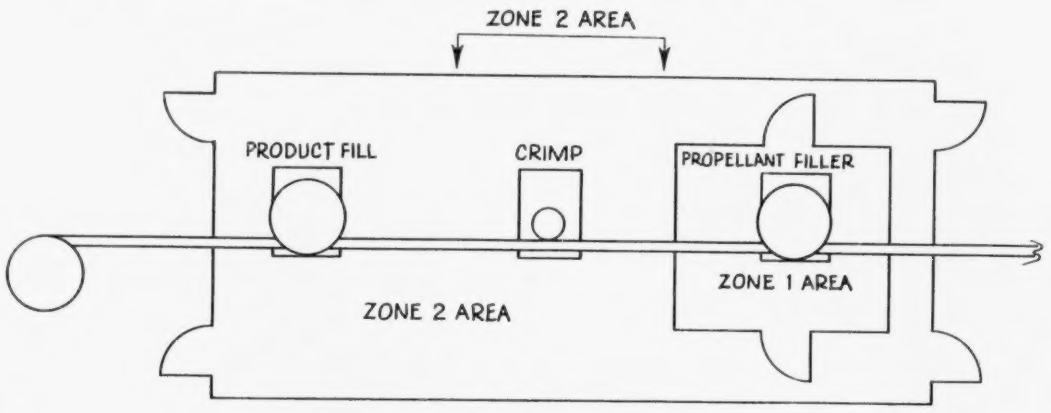

ZONE 2 AREA
PRODUCT FILL
CRIMP
PROPELLANT FILLER
ZONE 1 AREA
ZONE 2 AREA

Fig 13-2 Rotary Machine Filling
The separate enclosure of the propellant filler in a Zone 1 Area ensures better extraction with enclosed Zone 2 Area for the filling of products containing Highly Flammable Liquids.

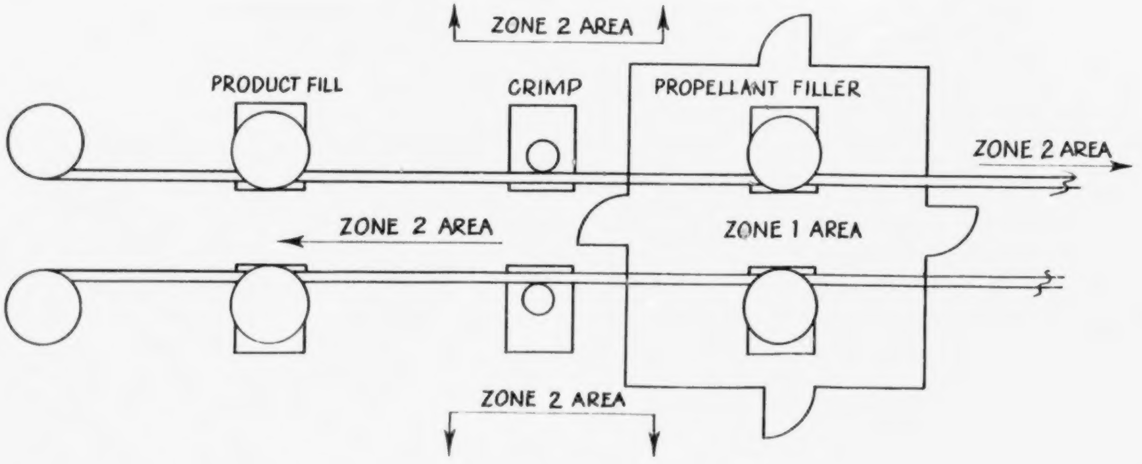
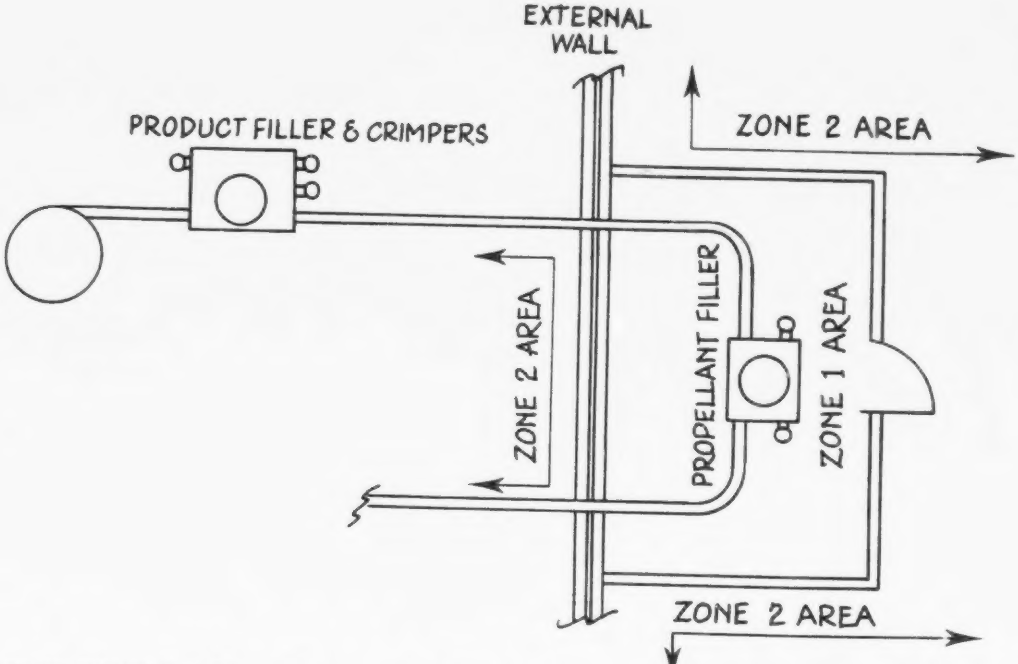

ZONE 2 AREA
PRODUCT FILL
CRIMP
PROPELLANT FILLER
ZONE 2 AREA
ZONE 2 AREA
ZONE 1 AREA
ZONE 2 AREA

Fig 13-3 Rotary Machine Filling
Zone 2 Area to extend to a distance to satsify the Factory Inspector especially for products with Highly Flammable Liquids. Zone 1 Area may be constructed for single or multiple lines with ventilation to suit.

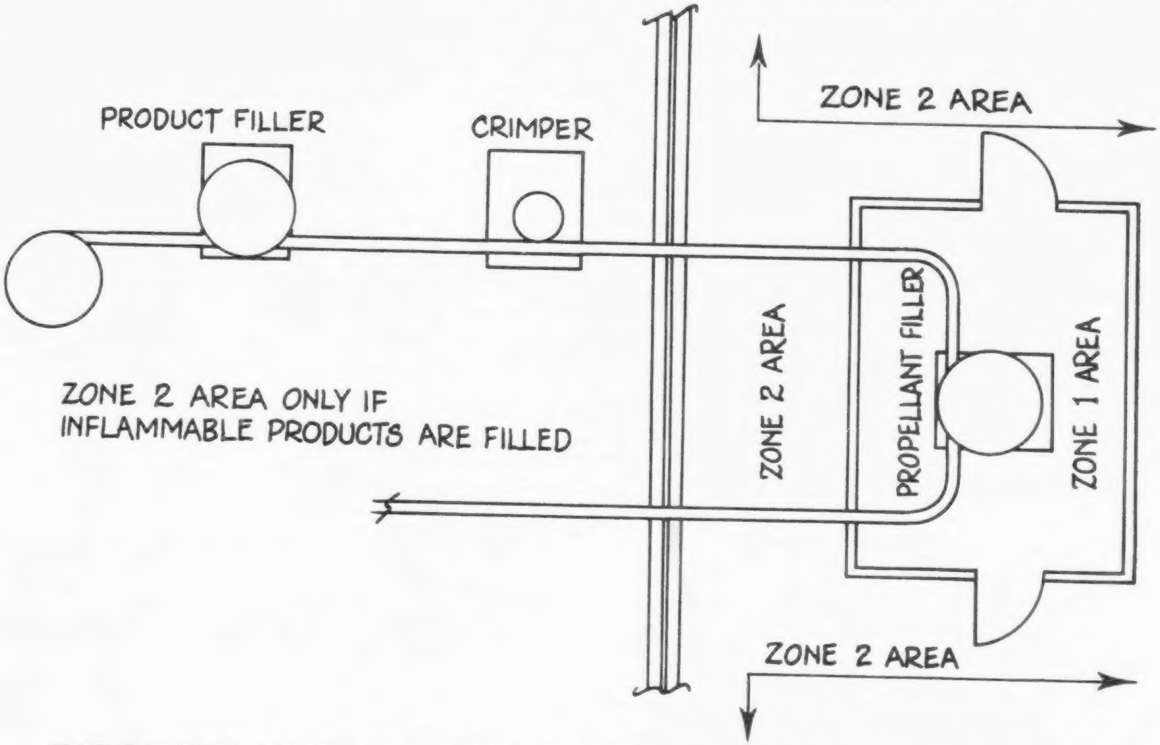
NOTE: In all cases separate ventilation may be required for operator comfort & health protection.

Drawings are schematic & not to scale

Fig 14


EXTERNAL WALL
PRODUCT FILLER & CRIMPERS
ZONE 2 AREA
ZONE 2 AREA
PROPELLANT FILLER
ZONE 1 AREA
ZONE 2 AREA

EXTENT OF ZONE 2 AREA INSIDE BUILDING MAY BE SET BY H.M. FACTORY INSPECTOR AND WILL INCLUDE PRODUCT FILLING IF INFLAMMABLE SOLVENTS ARE USED


ZONE 2 AREA
PRODUCT FILLER
CRIMPER
ZONE 2 AREA
PROPELLANT FILLER
ZONE 1 AREA
ZONE 2 AREA

ZONE 2 AREA ONLY IF INFLAMMABLE PRODUCTS ARE FILLED

THE REMOTE PROPELLANT FILLING BOOTH ENSURES A SAFE AREA INSIDE THE FACTORY PROVIDING NON FLAMMABLE PRODUCTS ARE FILLED

DRAWINGS ARE SCHEMATIC & NOT TO SCALE

LAYOUTS SHOWING FILLING BOOTHS EXTERNAL TO MAIN FACTORY BUILDINGS

In all layouts it is advisable to locate the rotary unscrambler tables outside the filling area and to pass the cans by conveyor through apertures in the separating walls, so keeping this can feeding, its associated combustible packing and any fork lift trucks, in a safe area. Filled cans may, of course, be conveyed from the filling room to the test and final packing operations in the same manner.

*'Dual Pak' and 'Star Pak' are machine names registered by Aerofill Ltd.

c) **Rotary filling machines (high speed)** — because of the greater output of these machines, the longer lines employed, the possibility of automatic valve sorting and insertion, the filling room Zone 2 may be fairly large with can handling through apertures as in 4b). The propellant filling machine may be housed in a 'walk-in' filling booth, fig. 13-1 or in a more restricted enclosure fixed to the machine itself, fig. 13-2.

If the former alternative is used with adequate ventilation and a controlled discipline on the opening of access doors, the rest of the filling room may be a Zone 2 area; with the latter the area surrounding the machine should be classified Zone 1 (by virtue of the opening of doors or hatches exposing the machine and possibly flammable liquid, gas or vapour to the surrounding area). No great advantage is secured apart from a possible saving in ventilation, except where a number of filling lines feed a common Zone 1 room, fig. 13-3, for propellant filling.

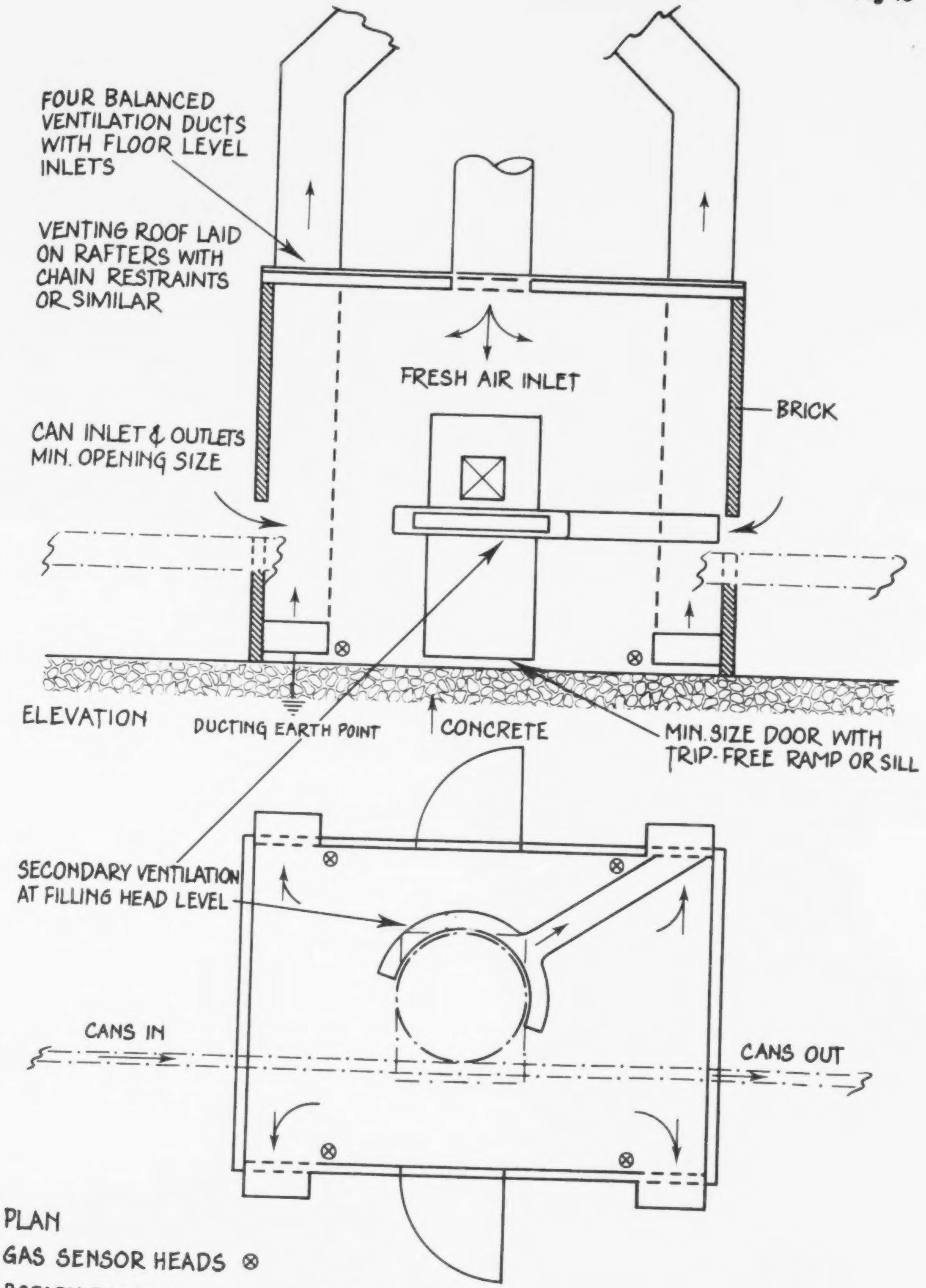
In situations where the filling room does not have a wall separating it from the rest of the factory area, Zone 2 conditions will extend, radiating from the enclosed propellant filling booth for a distance which will be decided upon by H.M. Factory Inspectorate.

Where space permits or during the consideration of new projects, the use of a self contained, isolated filling room in open air may be considered as a further alternative. With this method, the concentrate filled and crimped cans would be transferred by conveyor through an aperture in the factory wall to a separate filling room built on the existing building or remote from the main building — fig. 14. These two alternatives would still be classified Zone 1 with Zone 2 areas adjacent as indicated. If this principle is adopted the extent of the Zone 2 to Safe Area around the filling booth must be agreed with H. M. Factory Inspectorate and no subsequent building or intrusion made.

Where Fluorocarbon propellants are no longer to be used, vapour purging previously carried out with the use of propellant 12 vapour may be continued where compatible by the use of compressed gases; where the use of compressed gases is unsuitable vacuum crimping can be used.

Where an automatic checkweigher is to be sited after the propellant filler but within the Zone 2 filling room, for ease of data feedback, that machine shall

Fig 15

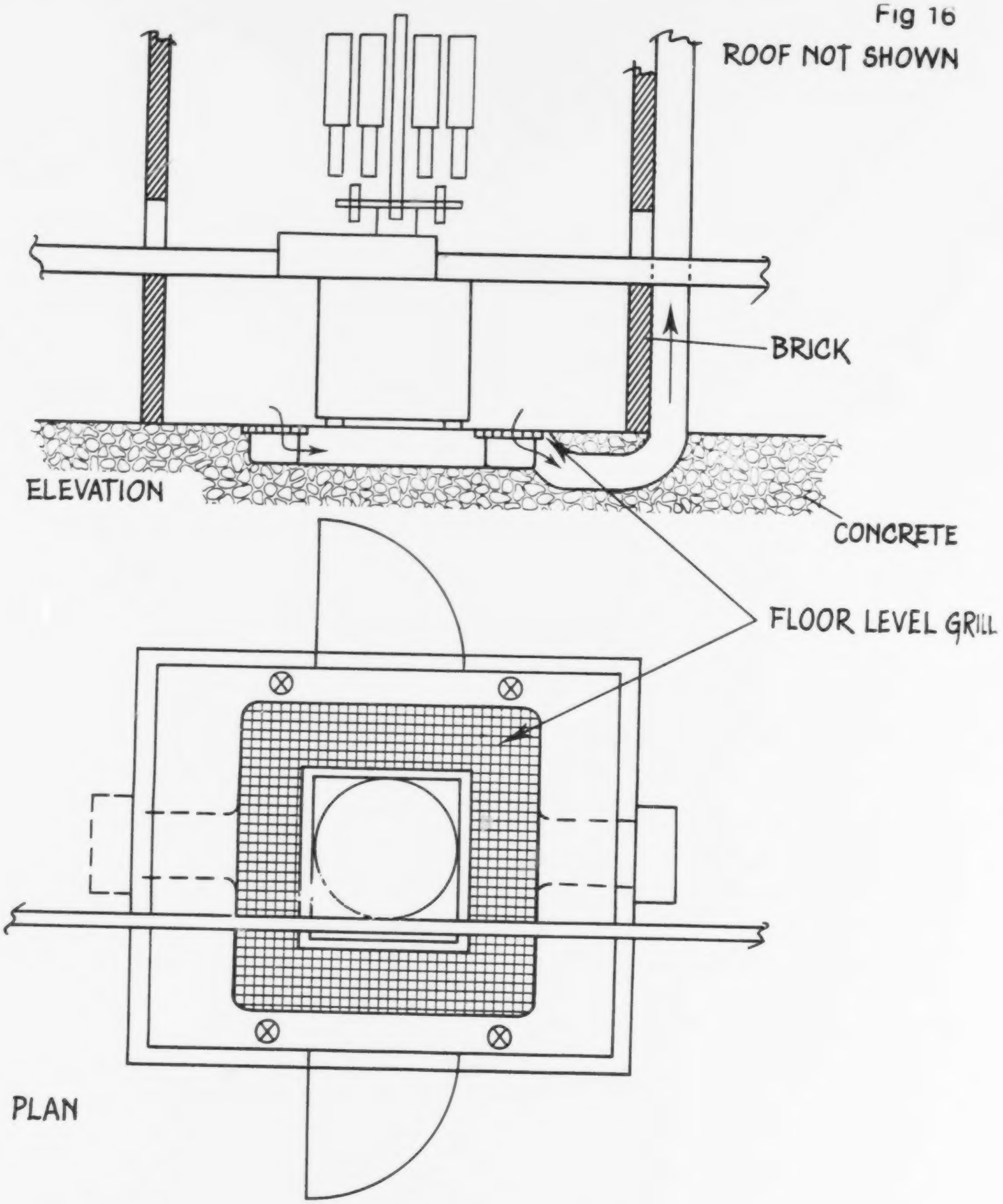

FOUR BALANCED VENTILATION DUCTS WITH FLOOR LEVEL INLETS
VENTING ROOF LAID ON RAFTERS WITH CHAIN RESTRAINTS OR SIMILAR
FRESH AIR INLET
BRICK
CAN INLET & OUTLETS MIN. OPENING SIZE
ELEVATION
DUCTING EARTH POINT
CONCRETE
MIN. SIZE DOOR WITH TRIP-FREE RAMP OR SILL
SECONDARY VENTILATION AT FILLING HEAD LEVEL
CANS IN
CANS OUT
PLAN

GAS SENSOR HEADS ⊗

ROTARY FILLER & CONVEYORS SHOWN THUS —·—·— & OMITTED IN ELEVATION
DRAWING IS SCHEMATIC & NOT TO SCALE

POSSIBLE SCHEME FOR FILLING BOOTH AND VENTILATION

Fig 16


ROOF NOT SHOWN
BRICK
ELEVATION
CONCRETE
FLOOR LEVEL GRILL
PLAN

Layout shows propellant filler surrounded by a ventilation channel surmounted by a floor level grill. The channel leads underground to the vertical ventilation duct. Care must be taken to design channel & duct to give a balanced ventilation in all directions around the machine. An alternative is to construct two ducts in opposite positions shown thus_ . _.Gas Sensors ⊗ moved nearer to doors fresh air inlet is from above

Drawing is schematic & is not to scale.

Possible scheme for below ground ventilation be flameproofed or intrinsically safe to approved standards. The checkweigher may be sited outside of the filling room, a reasonable distance from the aperture in the filling room wall and be ventilated at conveyor height.

Filling Room
The filling room enclosure and the propellant filling booth enclosure may be of brick or double skin steel partitioning sections bolted together and to the floor with a good seal and earthing bond, windows in clear shatterproof polycarbonates should be kept to a minimum, but where operators are permanently present, should be sufficient in size to overcome any claustrophobic effect. The doors should be smaller than standard, have a raised threshold, be close fitting in the architraves and open outwards. A minimum of two doors is recommended — their positioning to be more suitable for emergency exit than for servicing equipment. The roof shall be *laid on* rafters where necessary, with a good seal, but with corner chain restrictors common to explosion venting. Ideally, the venting should be through the roof of the factory, but where high roofs exist, the filling room and booth may have individual roofs at lower levels, providing there is an uninterrupted space above. In all cases, the height of the filling room and propellant filling booth should be adequate to the operation — 3m. may be considered sufficient for rotary machines.

Since the rooms and booths in our recommendations are square or rectangular in plan, we would recommend four balanced ventilation ducts in the corners with openings at near ground level as primary extract and with secondary ventilation at filling head level, — fig. 15. The gas sensor heads should be mounted adjacent to the lower duct openings at a side to take account of the position of the booth doors. The extract should pass through the roof to the highest possible point away from the roof valleys and rain water gulleys. Fresh air inlet should be remote from the outlet and should be so calculated as to supply sufficient air to create a negative pressure within the booth and be fed in at propellant filling room or booth roof level.

A channel in the floor surrounding the base of the propellant filler connected with the extract duct and topped with a perforated grille at floor level may be an alternative method of providing ventilation — fig. 16.

Smoke tracers and a portable velocity meter may be employed to test for draught patterns and the balancing of ventilation ducts.

In a well designed system, it may be agreed that normal operation will be conducted at 25% of the L.E.L. An 'orange' warning should be made by the sensors on detecting this level and above, whilst a 'red' warning (shut down) could be made when a head reports 50% of the L.E.L.

From the circumstances of the filling layout, consultation with H.M. Factory Inspector and the factors mentioned earlier plus a safety factor of say 2, a formula for the amount of air in cubic meters per minute to be introduced, mixed with any hydrocarbon vapour and extracted can be determined and duct and fan size gauged accordingly.

The time of progression from sensing at 25% of the L.E.L. to 50% of L.E.L. and shut down procedure may be increased or averted by the switching in of additional ventilation at the 25% level.

Any ventilation ducts, fans, light fittings and pipework shall not obstruct the venting roof principle.

All machinery should be guarded to ensure reasonably safe operation and protection for the workforce, but it should be noted that machine guards do not in themselves provide protection from the spread of hydrocarbon gas or vapour.

There may be superimposed upon these recommendations certain requirements of fire resistant structures in the segregation of Zone 1 and 2 areas from the rest of the factory.

In the packing area, the drive and equipment of the hot water test bath should be flameproofed with safe means of disposal of reject cans by automatic conveying or by collection in vented bins (metal) for frequent removal to a safe place.

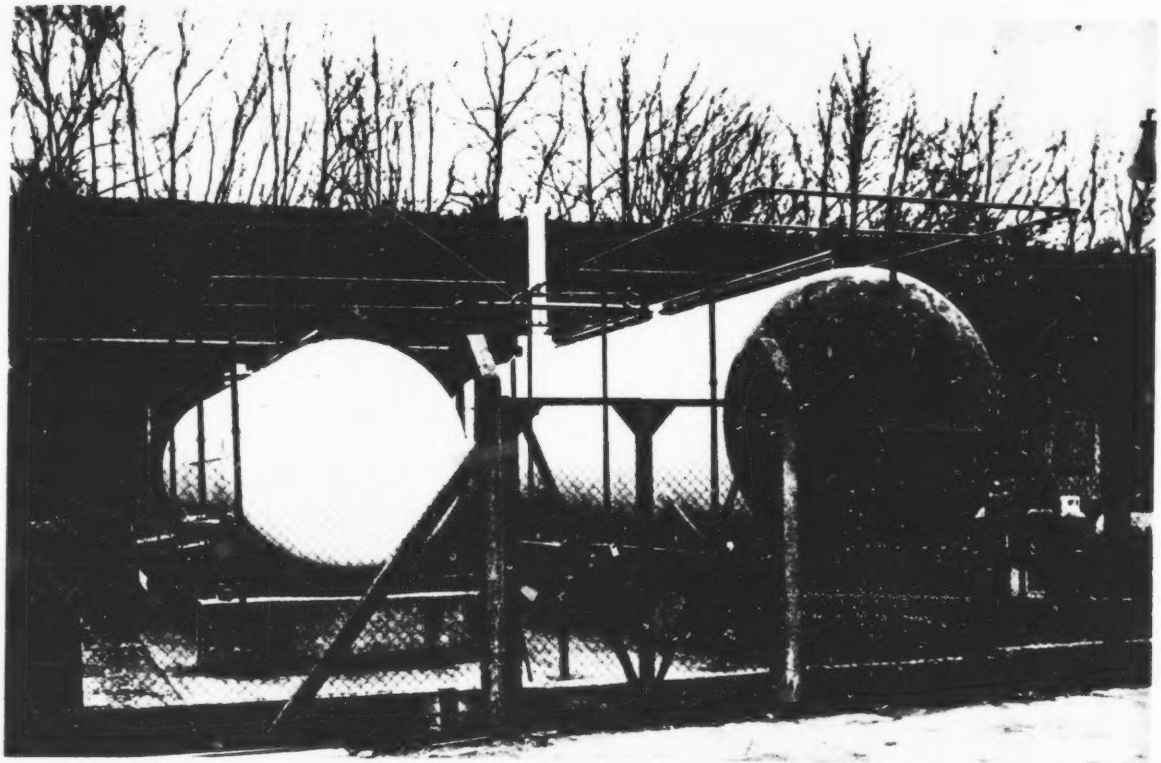
Automatic actuator placing machines should be flameproofed and conveyor height ventilation installed.

Other operations, in particular shrink wrapping, are dealt with in the B.A.M.A. publication.

5. Ventilate to remove any hazardous and harmful vapour

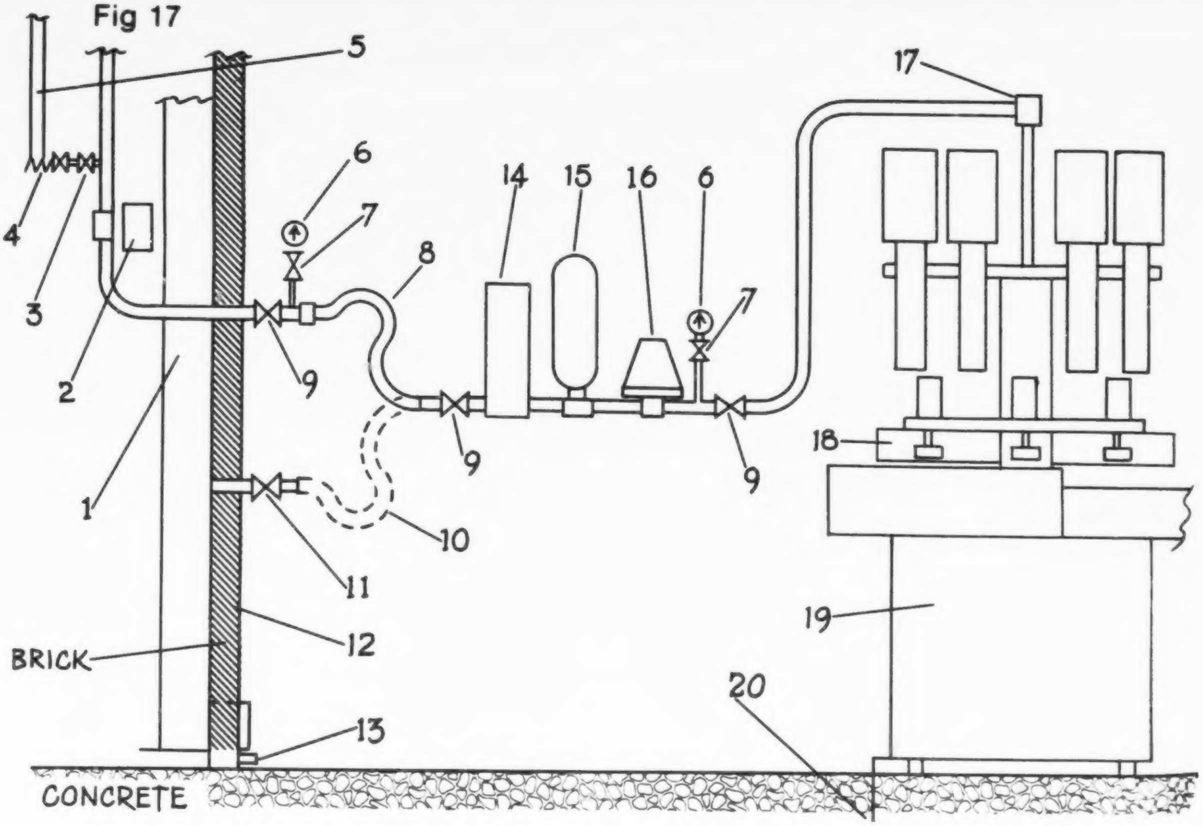
From the health point of view, there should be adequate ventilation to remove any toxic and noxious vapours with duct inlets at positions where any evaporation may occur and certainly at the concentrate filler nozzle level, with a minimum velocity of 46m. per minute across openings. For operator comfort within the filling room, air changes should be a minimum of the order of 25-30 changes per hour.

Ventilation is the first line of defence in the control and elimination of the hazard of hydrocarbon and should be so used to neutralise the inevitable release of a very small amount of hydrocarbon when the aerosol valve disconnects from the propellant filler. This gas amount can be calculated from the clearances between valve and filling adaptor, the rate of filling (cans per minute) is known, so is the expansion ratio (liquid gas to vapour)



12 tonnes and 30 tonnes tanks with Fixed Drench Sprinkler System

Fig 17



VIEW SHOWING SECTION OF PROPELLANT FILLING BOOTH

1 Extract Ventilation Duct with Floor Level Inlet
2 Solenoid Shut Off Valve (normally closed) Operated by Gas Sensors
3 Shut Off Valve (locked open — maintenance use only)
4 Hydrostatic Relief Valve
5 Vent Pipe to Atmosphere with Rain Cap
6 Pressure Gauge (Pump Line Pressure)
7 Shut Off Valve
8 Flexible Hose with Self Seal Quick Release Coupling
9 Shut Off Valve
10 Position of Flexible Hose for Gas Purging
11 Bleed Valve with Controlled Leakage into Ventilation Duct
12 Filling Booth Wall
13 Gas Sensor Head
14 Filter 10 Micron
15 Pressure Accumulator
16 Pressure Regulator — Line Pressure down to Machine Operating Pressure
17 Rotary Joint
18 Secondary Ventilation at Can Filling Level (into duct not shown)
19 Rotary Propellant Filling Machine
20 Machine Earthing Point

Drawing is schematic & is not to scale

Scheme for Supply & Connection of Propellant Line to Filling Machine of the hydrocarbon, at say 20°C (70°F). We also know that the lower explosive limit of butane in air is approximately 2%. In order, therefore, to create a safe atmosphere, we must supply to and mix with the released hydrocarbon sufficient quantitites of environmental air to produce a mixture that is below the Lower Explosive Limit (L.E.L.). The actual percentage below the L.E.L. which may be considered acceptable for normal operation (for an 'orange' warning and for a 'red' warning as detected by electro-catalytic monitoring systems) will be determined by the size and layout of the filling booths and the disposition of the ventilation openings.

The 'orange' warning should be somewhat muted to give warning of level change without provoking alarm. The 'red' warning should, through the sensors' relay system, shut off propellant supply at the filler and tank pump by use of flameproofed 'energised open/normally closed' solenoid valves; operate evacuation warning and any other procedures agreed with H.M. Factory Inspector and the Fire Brigade. The shut down procedure will switch off all electrical supply to the filling line and other equipment.

The ventilation system should be interlocked so that the filling line cannot be started without the ventilation and the ventilation shall be monitored by an air flow switch in the ducting that will shut down the line if the air velocity drops below set levels.

6. Ensure a safe routing of propellant pipework through the factory

Ideally, pipework should be routed from the tank farm to the filler in open air as far as possible. In its passage inside the factory, the pipework should be fixed firmly as high as possible but in accessible positions. The pipes should not be routed alongside electrical ducts or cables, steam pipes or heating systems, a continuous earth bond shall be maintained and pipes identified for hydrocarbon and directional flow in accordance with British Standard 1710 — 1975.

Immediately prior to their entry to the propellant filling booth, an emergency shut down valve should be fitted, with a manual shut off valve immediately inside the booth. It is advisable to pass incoming propellant through a fine filter, say 10 micron, to remove any fine particles that may affect seals and 'O' rings. To eliminate fluctuation in flow and pressure caused by intermittent demand it may be necessary to fit a hydraulic accumulator; whilst a pressure regulator should be fitted to reduce line pumping pressure down to that needed to support pressure filling ratios and filling accuracies. The final connection to the propellant filler may be flexible, but to British Standard 4089, whilst any quick release couplings should self-seal (all valves should be fire safe) fig. 17.

On machine changeover, the unwanted propellant within the machine may be safely purged by plugging the quick release coupling into a valve in the vent ducting to permit controlled release that will not overload the system.

7. Evaluate, install and maintain a safe operating procedure at all times and for all personnel

The sections of the B.A.M.A. 'Guide to Safety in Aerosol Manufacture' dealing with aerosol filling and subsequent testing and packing should be referred to; these recommendations and suggestions, together with procedural recommendations in the Health & Safety Executive's Code of Practice, etc; and the additional recommendations that we have set out in this handbook may be collated with numerical references to serve as official procedures for your company:

a) Start up procedure
b) Operational procedure
c) Shut down procedure
d) Changeover procedure
e) Emergency procedure

These procedures will vary according to the circumstance of each factory, its size, type and number of filling lines, a layout service plant and equipment and other factors. It is part of the Aerofill Service to undertake this task and to work with company representatives to produce a series of satisfactory procedures and to operate a check list service in order that necessary updating and maintenance of the procedures is carried out.

Section 9

THE LABORATORY AND PILOT LINE

Most aerosol filling operations will be supported by laboratory facilities for formulation, test and evaluation and perhaps process and quality control with pilot line operation in larger companies. It therefore follows that the scale of the laboratory operation will be proportional to the total size of the enterprise.

There is no single statutory regulation governing the operation of a laboratory and such as do apply do so in part. Abstracts from the Shops, Offices and Railways Act: the Highly Flammable Liquids and L.P. Gases Regulation; Regulations for Storage and Use of HFL's and Solvents; the Petroleum Consolidation and Mixtures Order 1928 and 1929 for storage mixing and use; the Medicines Act where appropriate as well as sensible and applicable parts of the various codes of practice identified in this handbook may all apply.

Where not governed by mandatory requirements, the laboratory layout and operation should be dictated by good safety sense in the same manner applicable to the main factory area and staff properly trained and instructed in the handling and use of hazardous materials.

Advice should be sought from H.M. Factory Inspectorate, the Fire Prevention Officer and from the technical advisory service of the supplier of propellants, solvents and raw materials.

In any event, the suppliers of these raw materials are required to present you with technical datasheets for each material, that identifies its physical properties, its hazards (flammability, flash point, toxicity etc.) safe handling, precautions and emergency action if required. These information sheets are mandatory under the Health & Safety At Work Act.

As the data contained in these information sheets applies to your total workforce in the factory as well as the laboratory, it is sensible that the Laboratory Manager be entrusted with the duty of requesting, receiving, cataloguing and ensuring that safe handling, mixing and use procedures based on these information sheets be disseminated throughout the factory in a correct manner.

Your Factory Doctor should be informed, consulted for advice and good procedures.

The design, construction and set-up of the laboratory will, of course, depend upon the size of the total undertaking, but it is unlikely that the supply of hydrocarbon will be required in anything larger than refillable cylinders. The cylinders awaiting use or empty awaiting collection by the supplier will be stored as set out in Section 5.

Those cylinders in use should be stored in the open at least on an outside wall in a well ventilated place with separation from other combustables, high flammable liquids and other gas cylinders. The cylinders should be chained secure in an upright condition suitably marked and identified as to their purpose; the key or shut-off valve knobs should not be removed and it it is recommended that a notice be fixed around the neck of the cylinders in use: vis

> 'Cylinder in use — shut-off valve open.
> Do not tamper or close except in emergency
> without reference to ....'
> (enter name of suitably qualified and
> responsible person).

If the laboratory is small, sample filling may be carried out in a fume cabinet that is completely flameproof and properly ventilated to a safe area; the front cover should be lowered as low as is practicable for hand operation of propellant filling. The air flow of ventilation across the opening should not be less than 46 metres per minute.

Whilst the filling of samples is in progress, all ignition sources in the laboratory should be turned off, a portable gas detector should be used to monitor the operation.

Ideally, the fume cabinet should be located on an outside wall and as isolated as possible, certainly from naked lights or flame and any source of ignition.

On a larger scale, the filling by laboratory Pilot or Dual Pak equipment including the product filling should be enclosed in a self-contained room well ventilated to a safe area with at least 25-30 air changes per hour. All equipment should be flameproofed and gas detectors strategically placed to sense unwarranted concentrations of hydrocarbon and able to bring a halt to filling until the atmosphere is cleared. Personnel should be trained to shut down and evacuate in the event of excessive escape.

A pilot line operation using a Dual Pak or the larger Star Pak equipment should be contained in a room which, in turn, should be considered a Zone 1 area and flameproofed and treated accordingly as with a production line of this type mentioned in Section 8.

Hot water leak and container testing should be carried out on all aerosols more especially since they will be formulated for test and evaluation and should be given 100% inspection. Leak test should be stringent to prevent unwarranted accumulation in store rooms and hot store.

Actuators should be fitted with a screwing action to prevent any hydrocarbon present in the dip tube being released by accidental operation of the valve.

Test spraying, evacuation tests and residue tests, etc., should be conducted in a fume cabinet with good ventilation with fan rate guaged to the rate of spray testing.

It is normal to expect that filled samples will be stored at ambient and elevated temperatures and for this reason we again stress the importance of the leak inspection. Leakage under hot storage conditions, of between 20°C-25°C, presents a greater hazard, since the hot store cannot be continuously ventilated to combat gas leaks. Detection units should be installed within the store to provide adequate warning of hydrocarbon gas and to switch on ventilation to clear the accumulation whilst switching off the source of heat.

In all cases it is recommended that windows in the room, fume cabinets and the filling room be fitted with clear polycarbonate sheet and that these windows be kept to the minimum area.

Personnel should wear cotton overall clothing to obviate static, should wear eye protection and be properly trained and instructed in safety procedures.

Section 10

DISPOSAL OF WASTE AND SCRAP

Regardless of the efficiency of any operation, there will be waste and scrap and since this contains highly flammable liquids, toxic materials and hydrocarbons, and combinations of all three, the disposal of this waste should be tackled with care and a sensible appreciation of its hazard.

Waste, whether liquid, solid or scrap aerosols is subject to the Control of Pollution Act 1974 which lays down certain controls, whereby the burden of responsibility for safe removal and disposal is chiefly with the aerosol manufacturer. Using the correct procedure, notify the local authorities of the nature and amount of waste; the contractors name and address; the location of approved disposal site; the nature of the disposal means. The local authorities in the disposal area if outside of the jurisdiction of the local authorities applicable to the manufacturer's works, should also be notified.

For disposal, we should consider two distinct categories: 1) **Liquid and/or solid waste** — Aerosol concentrates, left over concentrates after a run, surplus or obsolete and reject mixes, washings in either water or solvent thereby contaminated. 2) **Scrap aerosols** — Line scrap; empty, full or partly full, laboratory and quality control scrap; and obsolete aerosols from whatever source.

1) **Liquid/solid waste**
It is extremely unlikely that any company engaged in the production of aerosols may be granted any consent for the disposal of waste into surface water or foul drains.

However, consultation with your water and/or local authorities will establish what 'permitted quanitities' may be accepted; any such waste would need to be biodegradeable and in quantities acceptable to the drainage/river system or the filter beds. At the very best the waste water from the hot water test baths may be acceptable under certain conditions.

It therefore follows that the concentrate mixing and the area in the vicinity of the product fillers be drained to a sump for periodic removal and disposal within the requirements of the Act.

2) **Scrap aerosols**
There are two methods of dealing with scrap aerosols.

i) **Shredding** — this process passes the scrap through powerful jaws from a funnel type hopper which punctures and shreds the can into manageable pieces. This releases the hydrocarbon propellant to evaporate around the machine and the product to be drained by gravity down chutes for collection in a sump. This type of installation needs proper siting under flameproof conditions with the best possible separation distances from any fixed source of ignition. The machine, chutes and sump should be well ventilated to a safe height and the plant operated at frequent intervals throughout the working day as the scrap is produced; rather than operating for a set period to process the day's scrap in one quick batch. The hopper should be fed in small quantities on a 'little and often' basis for good safety, for an overworked shredder can release an appreciable amount of vapour gas in a very quick time, i.e. a scrap rate of 0.5% and a fill of 10,000 units with a 50gm butane fill will produce a flammable cloud in air to the order of 60 cu. mtrs. (2000 cu. ft.) and as the machine can shred the 25 cans of scrap of the example in less than 3 minutes, the gravity of the hazard may be readily appreciated.

ii) **Tip disposal** — this method may be more acceptable where there is insufficient 'natural ventilation' for a shredding operation. Within the requirements of the Act and with proper procedure, it is possible for tip operators, where sanctioned, to supply on a hire/demurrage basis a large open skip (20-30 cubic metres) for collection and transport of scrap to the tip. It is necessary to site the skip in a well ventilated area with a suitable portable shield to prevent the ingress of rain diluting any ensueing liquid waste for possible leakage on public highway during transport from the factory. To prevent the possibility of leakage due to pressure from weight of cans in the skip, it is recommended that scrap aerosols are fitted with an overcap and that scrap is bulldozed immediately upon receipt at the tip to prevent any unauthorised salvage.

In all cases it is recommended that the Factory Inspectorate and the Fire Prevention Officer be consulted concerning the siting of shredding machines or portable skips.

Local authorities have the power of inspection under the Act.

Those companies who may wish to consider on site treatment of trade effluent should note that this is only economic for very large operations or where waste is produced from other processes as well as aerosols. This treatment is not total, leaving a concentrated sludge to be disposed of as laid down in the Act.

Incineration of waste may be considered but again demands high throughput or a specially designed project in conjunction with a fuel burning boiler.

Section 11

FINISHED GOODS

The storage of finished goods in the factory warehouse area may be governed in some way by local regulations and bye-laws. Apart from these requirements aerosols, dependent upon formulations and contents, may be governed by:

a) The Petroleum Mixtures Act and Orders, wherein a petroleum licence is required (see section 7) to store, mix and use products containing petroleum substances within the meaning of the Act. Advice may be sought from Fire Prevention Officer and County Secretariat.

b) The Highly Flammable Liquids and Liquified Petroleum Gases Regulation 1972, applies to aerosols containing more than 500cc of total contents. Aerosols containing in excess of 500cc are classified as flammable when they contain more than 45% or 250gms of liquids with a flash point of less than 32°C (90°F) aggregated with any flammable gas. Aerosols classified as flammable must be labelled 'Flammable — do not use near fire or flame' in accordance with agreements with H.M. Factory Inspectorate and stored in a fire resistant structure as set down in the regulations.

In the interests of safe storage, the filler is advised to check against accidental spraying and release of hydrocarbons due to weight of stored and palletised aerosols:

1) In cases and cartons, check the total weight of the stack against the collapse resistance of the carton and overcap.

2) Check total weight of stack against collapse resistance of overcap when shrinkwrapping is used without support from any outer carton.

It is recommended that smoking be prohibited throughout the whole storage area and notices displayed.

It is recommended that there be adequate gangways and that goods are not left in these gangways.

The warehouse should be dry and as cool and as well ventilated as possible.

Hydrocarbon filled aerosols should not be stored in basements or areas with open drains.

All storage should be away from stoves, radiators, boilers and other heat sources.

Adequate means of fire fighting and fire exit should be provided in consultation with the Fire Prevention Officer.

Section 12

SAFETY AND FIRE PRECAUTIONS

The possibility of any outbreak of fire can best be minimised by sound engineering in the initial design and layout of the tank installation and the filling line, and also by a critical analysis of each facet of the total operation and its hazards. In co-operation with authorities and competent advice, written procedures for start up, shut down and operation of emergency procedures should be produced. From these masters an itemised checklist, numbered and in logic sequence should be prepared and used for each individual part of the process. Tanks, pumps, valves, pipelines, etc., should be given numerical or alpha-numeric references and identified on the checklist. Ideally, the procedures should be a two man operation and signatures obtained to record the correct operation and sequence of each phase.

Staff of adequate education and training should be instructed in these procedures, not just to follow a sequence of operations but with a knowledge of the principles of the operations and the need for adherence to the discipline.

Maintenance and leak check procedures should be drawn up and a 'permit to work' system installed where maintenance or overhaul is required. The work and conditions of any subcontractor should be closely controlled and monitored at all times.

Periodic meetings of all concerned in the total operation should be held and from this feedback update, revision and improvement of procedures may be made.

Adequate water supply either mains or from storage tanks should be provided for fire protection, hose reels may be suitable for small installations but fixed spray systems are strongly recommended both within the factory and at the tank farm (favourable insurance premiums may result). The strategy for fire precautions should be aimed at keeping a fire unconnected with the hydrocarbon storage or use from effecting the hydrocarbon installation as well as protecting the hydrocarbon installation itself.

The production and warehouse areas of the factory may be protected by a sprinkler system with individually fused spray heads, but it may be preferred to protect areas such as the mixing room tanks, solvent tanks and the hydrocarbon installation with a total deluge system where a number of spray heads in a group or groups are activated automatically from the fuse bulb in any one spray head. The system should also be capable of manual operation. In the case of the hydrocarbon tanks, in an emergency the surface area shall be drenched at a rate 10 litres per square metre (0.2 gals. per square foot) whilst pump sets, destench columns etc. should also be covered by the water spray heads.

Suitable fire points and alarm systems should be installed in consultation with the insurance Company and the Fire Prevention Officer. The sprinkler installation company can also advise on good practices and on the setup of a master control and enunciator to give fire incident location warning. Gas sensor modules should be located in a position that can be monitored during normal working hours and is easily accessible for the local Fire Brigade.

The Fire Prevention Officer and Insurance Company may be consulted for advice on number, type and siting of hand fire fighting appliances. It should be noted that CO_2 and Dry Powder units to British Standard 3465 may be used on hydrocarbon — foam units are not considered suitable.

All operators should wear cotton or similar non-static producing clothing. All matches and smoking materials should be prohibited in the factory area and advice sought from the Fire Prevention Officer and H.M. Factory Inspectorate concerning the type, wording and location of No Smoking and other warning and instructional signs.

According to the category of Zone areas, all electrical equipment shall be flameproofed to British Standard Code of Practice CP1003 and BS5345 and the selection to British Standard BS4137, with design to British Standard BS229. Where intrinsically safe equipment is required, this shall also be to CP1003 certified by the manufacturer.

Other standards applicable to the electrical equipment and fire alarms may be found in the Bibliography of Standards and Codes of Practice at the rear of the handbook.

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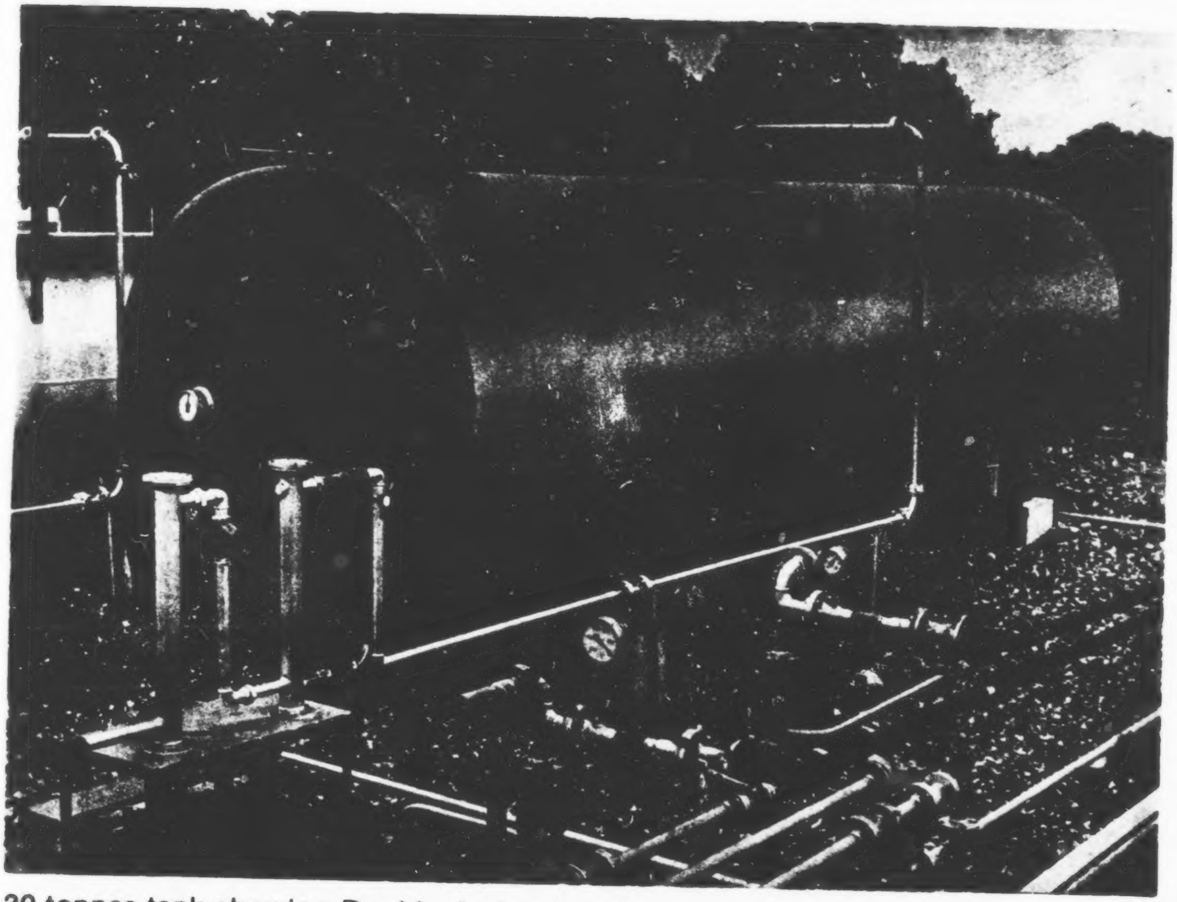

30 tonnes tank showing Double destench column

The gas sensors, may be electro-catalytic suitable for hydrocarbons and as described in the Department of Employment Technical Data Note No.45. 'Industrial Use of Flammable Gas Detectors'. These units usually have two adjustable settings which trigger relays to actuate shut down valves, alarms, etc. In accordance with agreed procedures.

The units may be used in the presence of fluorocarbons, however, in extreme circumsntances the hot element may become inhibited due to possible coating by chlorine from the fluorocarbon vapour. This does not cause any permanent damage and will be burnt off by hydrocarbon passing over the element, the response time may be slightly impaired.

A method to offset this problem is to fit a blanking cap over the sensing head during the filling of fluorocarbons.

Multi-point infra red sensor/analyser systems may also be used and may be considered where fluorocarbon and hydrocarbon propellants are filled simultaneously causing concern regarding the possible contamination of the electro-catalytic systems.

The principle of the infra red system is to extract a sample of the atmosphere in the monitored area and to convey the sample in cyclic pulses via plastic tubes to the remotely located analyser which may be calibrated to give warnings at appropriate levels of the L.E.L.

These systems usually employ a number of sampling tubes (multi-point) leading to one analyser and the frequency and sequence of the samples from the tubes would be decided upon examination of each separate installation. The tubes may be of lengths up to 500 metres which, in turn, may affect the response time.

The units must be recalibrated from time to time using trace gases for the appropriate orange and red warning levels of the L.E.L. Since the instrument module is remote from the sensing head a portable two way phone system may be used by the two man team for calibration purposes at a time when the production unit is shut down.

Precautions should be taken against static electricity by ensuring good design of installation and earth continuity throughout the tank farm, pumps and pipework, filling machinery as well as solvent storage, handling mixing and filling. Precautions should also be taken within the laboratory.

Static is the electrification of materials through physical contact and separation (single or multi-cycle) and the resultant static effects stem from the positive and negative charges so formed. The generation of static *cannot be prevented;* it is inherent in the interface of any dissimilar materials.

To reduce the risk of ignition, the following guidelines should be observed:-

1. Reduce risk of static built-up by firm fixing of all equipment and pipework to reduce vibration and use anti-static materials wherever possible.

2. Ensure all equipment is adequately bonded and checked regularly for continuity, to prevent accumulation of charges and differences in electrical potential occurring.

3. Flameproof all electrical equipment and avoid naked light and incendive sparking.

4. Ventilate well and adopt good safety and checking procedures to leakage or accumulation of ignitable mixture.

In our opinion, the statements in this Section represent good practice and therefore form recommendations. Any compliance does not confer immunity from relevant statutory or legal requirements.

Section 13

FURTHER INFORMATION

Aerofill Limited, as a major supplier of aerosol filling equipment, will be happy to provide advice and assistance to existing and prospective customers on installations using any category of propellant.

In recognition of the trend towards the use of hydrocarbons as aerosol propellants, considerable research has been undertaken. Much of the data obtained, as may be generally applied, is contained in this handbook. Our sales engineers, supported by our internal engineering expertise, will provide such assistance in interpretation to particular installations as may be practical.

Copies of the main Statutes, Codes of Practice and other publications mentioned in the text may be supplied with this handbook or obtained from Aerofill. These are charged for, simply saving the time, effort and research of customers obtaining them direct from the various sources. These mandatory requirements are supported by our 19 years of accumulated experience in the industry.

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Bibliography

In anticipation of a need Aerofill Ltd have acquired a stock of the principal publications mentioned in this handbook. This stock enables the reader to obtain a library of Codes of Practice, Recommendations, British Standards and other publications from one source.

1. Code of Practice for the storage of LPG at fixed installation — Health & Safety Executive.
2. Code of Practice for the keeping of LPG in Cylinders and Similar Containers — Health & Safety Executive.
3. Code of Practice for Electrical Apparatus associated equipment for the use in explosive atmosphere of gas or vapour — British Standard CP1003 — 3 parts.
4. Code of Practice for the selection, installation and maintenance of electrical apparatus for use in potentially explosive atmospheres — British Standard 5345.
5. Code of Practice for Fire Precautions in chemical plant — British Standard CP 3013.
6. Flameproof enclosure of Electrical Apparatus — British Standard 229.
7. Guide to the selection of Electrical Equipment for the use of Division (now referred to as Zone) 2 Areas — British Standard 4137.
8. Rubber Hose and Hose Assemblies for LPG Lines — British Standard 4089.
9. Specification for Identification of Pipelines — British Standard 1710.
10. Petroleum Acts 1928-1929 — H.M. Stationery Office.
11. Petroleum (Inflammable Liquids) Order 1971 — H.M.S.O.
12. The Highly Flammable Liquids and Liquiefied Petroleum Gas Regulations 1972 — H.M.S.O.
13. Guide to Safety in Aerosol Manufacture — British Aerosol Manufactures Association.
14. Threshold Limit Values — Technical Data Note — Health & Safety Executive.
15. Industrial use of Flammable Gas Detectors — Technical Data Note — Health & Safety Executive.

Additionally there are many other Codes of Practice, Recommendations and British Standards that cover every facet of an installation which may be easily compiled from the lengthy Bibliography that will be found in the appendix of the aforementioned list of publications.

Representation to the following may be made for full lists of publications on the subjects of:-

1. Tanks, pipelines, pumps, valve-fittings foundations and installations in respect of LPG.
2. Electrical apparatus, lights, fire alarms and wiring.
3. Fire precautions, appliances, sprinkler systems and installation.

4. Good operational practices. Codes of Practice etc.

British Standards Institution
2 Park Street
London W1A 2BS

Tel: 01-629 9000

Publications from: 101 Pentonville Road
London N1 9ND

Tel: 01-837 8801

The Liquiefied Petroleum Gas Industry Technical Association

All publications obtainable from: William Culross & Son Ltd
Coupar
Angus
Scotland

Her Majesty's Stationery Office
49 High Holborn
London WC1V GHB

For: Acts of Parliament & Statutory Orders
Health & Safety Executive publications

British Aerosol Manufacturers Association
Alembic House
93 Albert Embankment
London SE1 7TV

Tel: 01-582 1115

Fire Protection Association
Aldermary House
Queen Street
London EC4N 1TJ

Tel: 01-248 5222

The information in this guide is as accurate as possible but Aerofill Ltd cannot accept any responsibility should it be found that the information is inaccurate or incomplete, or becomes so, as a result of future developments.

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APPENDIX G

METRIC (SI) CONVERSION FACTORS

APPENDIX G

METRIC (SI) CONVERSION FACTORS

Quantity	To Convert From	To	Multiply By
Length:	in	cm	2.54
	ft	m	0.3048
Area:	in^2	cm^2	6.4516
	ft^2	m^2	0.0929
Volume:	in^3	cm^3	16.39
	ft^3	m^3	0.0283
	gal	m^3	0.0038
Mass (weight):	oz (avoir.)	kg	0.0283
	lb	kg	0.4536
	short ton (ton)	Mg	0.9072
	short ton (ton)	metric ton (t)	0.9072
Pressure:	atm	kPa	101.3
	mm Hg	KPa	0.133
	psia	kPa	6.895
	psig	kPa*	(psig)+14.696)x(6.895)
Temperature:	°F	°C*	(5/9)x(°F-32)
	°C	K*	°C+273.15
Caloric Value:	Btu/lb	kJ/kg	2.326
Enthalpy:	Btu/lbmol	kJ/kgmol	2.326
	kcal/gmol	kJ/kgmol	4.184
Specific-Heat Capacity:	Btu/lb-°F	kJ/kg-°C	4.1868
Density:	lb/ft^3	kg/m^3	16.02
	lb/gal	kg/m^3	119.8
Concentration:	oz/gal	kg/m^3	
	quarts/gal	cm^3/m^3	25,000
Flowrate:	gal/min	m^3/min	0.0038
	gal/day	m^3/day	0.0038
	ft^3/min	m^3/day	0.0283
Velocity:	ft/min	m/min	0.3048
	ft/sec	m/sec	0.3048
Viscosity:	centipoise (CP)	Pa-s (kg/m-s)	0.001

*Calculate as indicated

APPENDIX H

AEROSOL FORMULATIONS

The following tables present current formulations for several aerosol products in the categories of:

- Personal Products (Tables H-1 through H-6);
- Household Products (Tables H-7 through H-10);
- Automotive/Industrial Products (Tables H-11 and H-12);
- Paints and Finishes (Table H-13);
- Insect Sprays (Tables H-14 and H-15);
- Food Products (Table H-16); and
- Animal Products (Table H-17).

The formulations list typical product weight, chemical compound names, and composition by percent and weight as "propellant" and "other."

TABLE H-1. HAIRSPRAY FORMULATIONS

Product Formula	Average Product Weight oz.	Propellant		Other	
		%	oz.	%	oz.
Hair Spray: Reg Hold - 1 (1)[a]	10.10				
Gantrez ES-225 (50% in EtOH)			0.00	4.00	0.40
N,N,-Dimethyl-octadecylamine			0.00	0.29	0.03
Dimethyl Phthalate			0.00	0.03	0.00
DC Fluid #193			0.00	0.02	0.00
Fragrance			0.00	0.10	0.01
S. D. Alcohol 40-2 (Anhydrous)			0.00	67.56	6.82
Propellant A-31 or A-40		28.00	2.83		0.00
TOTAL	10.10	28.00	2.83	72.00	7.27
Hair Spray: Reg Hold - 2 (1)	10.10				
Gantrez ES-225 (50% in EtOH)			0.00	4.00	0.40
Amino-methyl-propanol (95%)			0.00	0.09	0.01
DC Fluid #193			0.00	0.02	0.00
Fragrance			0.00	0.10	0.01
De-ionized Water			0.00	8.79	0.89
S. D. Alcohol 40-2 (Anhydrous)			0.00	61.00	6.16
Propellant A-31 or A-40		26.00	2.63		0.00
TOTAL	10.10	26.00	2.63	74.00	7.47
Hair Spray: Reg Hold - 3 (1)	10.10				
Resyn 28-2930 (100%)			0.00	2.50	0.25
Amino-methyl-propanol (95%)			0.00	0.20	0.02
Dimethyl Phthalate			0.00	0.03	0.00
DC Fluid #193			0.00	0.04	0.00
Disodium Dodecylsulfosuccinate			0.00	0.20	0.02
Sodium benzoate			0.00	0.08	0.01
Fragrance			0.00	0.15	0.02
De-ionized Water			0.00	16.00	1.62
S. D. Alcohol 40-2 (Anhydrous)			0.00	44.80	4.52
Dimethyl ether		36.00	3.64		0.00
TOTAL	10.10	36.00	3.64	64.00	6.46

(Continued)

TABLE H-1. (Continued)

Product Formula	Average Product Weight oz.	Propellant %	Propellant oz.	Other %	Other oz.
Hair Spray: Reg Hold - 4 (1)	10.10				
Resyn 28-2930 (100%)			0.00	2.50	0.25
Amino-methyl-propanol (95%)			0.00	0.18	0.02
DC Fluid #193			0.00	0.06	0.01
Disodium Dodecylsulfosuccinate			0.00	0.20	0.02
Sodium benzoate			0.00	0.08	0.01
Fragrance			0.00	0.15	0.02
De-ionized Water			0.00	32.00	3.23
S. D. Alcohol 40-2 (Anhydrous)			0.00	28.83	2.91
Dimethyl ether		36.00	3.64		0.00
TOTAL	10.10	36.00	3.64	64.00	6.46

*Indicates sources of formulation data (see References at end of this Appendix).

TABLE H-2. SHAVING GEL/CREAM FORMULATIONS

	Average Product Weight	Propellant		Other	
Product Formula	oz.	%	oz.	%	oz.
Shaving Gel (2)	8.00				
Stearic acid (95% purity)			0.00	2.00	0.16
Palmitic acid (97% purity)			0.00	5.80	0.46
Polyoxyethylene cetyl ether			0.00	1.00	0.08
Hydroxyalkyl cellulose			0.00	0.07	0.01
Carbopol 934			0.00	0.18	0.01
Propylene glycol dipelargonate			0.00	2.75	0.22
Sorbitol (70% solution)			0.00	10.00	0.80
Propylene glycol			0.00	3.30	0.26
Triethanolamine			0.00	4.20	0.34
Water			0.00	67.95	5.44
n-butane		0.55	0.04		0.00
n-pentane			0.00	2.20	0.18
TOTAL	8.00	0.55	0.04	99.45	7.96
Shaving Cream - 1 (1)	8.00				
De-ionized Water			0.00	74.90	5.99
Lauric/Mystiric Acids			0.00	1.50	0.12
Stearic Acid (Triple X)			0.00	6.00	0.48
Lauryl/Myristyl Diethanolamine			0.00	0.50	0.04
Triethanolamine (99%)			0.00	3.90	0.31
Cetyl Alcohol, N. F.			0.00	0.50	0.04
Glycerin - 96%, U. S. P.			0.00	5.80	0.46
Mineral Oil, N. F. Grade			0.00	2.40	0.19
Methyl p.hydroxybenzoate			0.00	0.10	0.01
n.Propyl p.hydroxybenzoate			0.00	0.03	0.00
Fragrance			0.00	0.67	0.05
Lanolin Derivative			0.00	0.50	0.04
Propellant A-46		3.20	0.26		0.00
TOTAL	8.00	3.20	0.26	96.80	7.74

(Continued)

TABLE H-2. (Continued)

Product Formula	Average Product Weight oz.	Propellant		Other	
		%	oz.	%	oz.
Shaving Cream - 2 (1)	8.00				
De-ionized Water			0.00	79.50	6.36
Lauric/Mystiric Acids			0.00	1.00	0.08
Stearic Acid (Triple X)			0.00	7.00	0.56
Lauryl/Myristyl Diethanolamine			0.00	2.00	0.16
Sodium Hydroxide			0.00	0.50	0.04
Potassium Hydroxide			0.00	2.25	0.18
Glycerin - 96%, U. S. P.			0.00	4.00	0.32
Polyvinylpyrrolidone K30			0.00	0.15	0.01
Fragrance			0.00	0.30	0.02
Lanolin Derivative			0.00	0.20	0.02
Propellant A-46		3.10	0.25	0.00	0.00
TOTAL	8.00	3.10	0.25	96.90	7.75
Shaving Cream - 3 (1)	8.00				
De-ionized Water			0.00	78.10	6.25
Lauric/Mystiric Acids			0.00	0.70	0.06
Stearic Acid (Triple X)			0.00	8.00	0.64
Sodium Lauryl Sulfate (30% Water Solution)			0.00	1.50	0.12
Potassium Hydroxide			0.00	0.40	0.03
Triethanolamine (99%)			0.00	3.00	0.24
Glycerin - 96%, U. S. P.			0.00	2.50	0.20
Methyl p.hydroxybenzoate			0.00	0.10	0.01
n.Propyl p.hydroxybenzoate			0.00	0.04	0.00
Fragrance			0.00	0.36	0.03
Lanolin Derivative			0.00	2.00	0.16
Propellant A-46		3.30	0.26		0.00
TOTAL	8.00	3.30	0.26	96.70	7.74

TABLE H-3. DEODORANT/ANTIPERSPIRANT FORMULATIONS

	Average Product Weight	Propellant		Other	
Product Formula	oz.	%	oz.	%	oz.
Antiperspirant - (1)	4.00				
Aluminum Chlorohydrate			0.00	8.00	0.32
Quaternium 18 Hectorite (Bentonite 38)			0.00	0.82	0.03
S. D. Alcohol 40-2 (Anhydrous)			0.00	0.80	0.03
Dimethylsilicone (500 cstks.)			0.00	1.50	0.06
Isopropyl Myristate			0.00	1.00	0.04
Cyclomethicone F-251			0.00	7.63	0.31
Perfume Oil			0.00	0.25	0.01
Propellant A-31 or A-46		80.00	3.20		0.00
TOTAL	4.00	80.00	3.20	20.00	0.80
Personal Deodorant -1 (1)	4.00				
Irgasan DP-3000* Germicide			0.00	0.11	0.00
Propylene Glycol			0.00	1.50	0.06
Fragrance			0.00	0.35	0.01
S. D. Alcohol 40-2 (Anhydrous)			0.00	58.00	2.32
Iso-butane (A-31)		40.00	1.60		0.00
TOTAL	4.00	40.00	1.60	59.96	2.40
Personal Deodorant - 2 (1)	4.00				
Benzthionium Chloride			0.00	0.20	0.01
Dipropylene Glycol			0.00	1.05	0.04
Fragrance			0.00	0.25	0.01
S. D. Alcohol 40-2 (Anhydrous)			0.00	68.50	2.74
Propellant Blend A-46 16 w.% Propane in Iso-butane		30.00	1.20		0.00
TOTAL	4.00	30.00	1.20	70.00	2.80

(Continued)

TABLE H-3. (Continued)

Product Formula	Average Product Weight oz.	Propellant		Other	
		%	oz.	%	oz.
Personal Deodorant - 3 (1)	4.00				
Methyl p-Hydroxybenzoate			0.00	0.03	0.00
n.Propyl p-Hydroxybenzoate			0.00	0.06	0.00
Benzyl p-hydroxybenzoate			0.00	0.08	0.00
Propylene Glycol, U. S. P.			0.00	1.03	0.04
Fragrance			0.00	0.30	0.01
S. D. Alcohol 40-2 (Anhydrous)			0.00	63.50	2.54
Propellant Blend A-46		35.00	1.40		0.00
16 w.% Propane in Iso-butane					
TOTAL	4.00	35.00	1.40	65.00	2.60
Personal Deodorant - 4 (1)	4.00				
Irgasan DP-3000* Germicide			0.00	0.12	0.00
Dipropylene Glycol			0.00	2.00	0.08
Zinc Phenolsulfate***			0.00	1.00	0.04
Fragrance			0.00	0.38	0.02
S. D. Alcohol 40-2 (Anhydrous)			0.00	13.35	0.53
De-ionized water			0.00	47.00	1.88
Sodium Benzoate			0.00	0.15	0.01
Dimethyl ether		36.00	1.44	0.00	0.00
TOTAL	4.00	36.00	1.44	64.00	2.56

*2,4,4'-Trichloro-2'-hydroxydiphenylether

TABLE H-4. COLOGNE FORMULATIONS

	Average Product Weight	Propellant		Other	
Product Formula	oz.	%	oz.	%	oz.
Cologne - 1 (1)	2.00				
Fragrance			0.00	4.00	0.08
Di-n.butyl Phthalate			0.00	2.00	0.04
Sodium Saccharinate			0.00	0.01	0.00
FD&C and/or D&C Dye Solution			0.00	0.09	0.00
S. D. Alcohol 40 of 39C (Anhydrous)			0.00	65.00	1.30
De-ionized Water			0.00	13.00	0.26
HFC-152a or HFC-22		15.90	0.32		0.00
TOTAL	2.00	15.90	0.32	84.10	1.68
Cologne - 2 (1)	2.00				
Fragrance			0.00	4.00	0.08
S.D. Alcohol 40 or 39C (Anhydrous)			0.00	76.00	1.52
Iso-butane A-31		20.00	0.40		0.00
TOTAL	2.00	20.00	0.40	80.00	1.60

TABLE H-5. OTHER HAIR PRODUCTS FORMULATIONS

Product Formula	Average Product Weight oz.	Propellant %	Propellant oz.	Other %	Other oz.
Hair Mousse - 1 (1)	10.00				
Polyquaternium 4			0.00	0.60	0.06
Dimethacone			0.00	0.15	0.02
Arquad T-50			0.00	0.10	0.01
Octoxynol 9			0.00	0.15	0.02
Emulsifying Wax NF			0.00	0.15	0.02
Deionized Water			0.00	75.85	7.58
Perfume Oil			0.00	0.10	0.01
S.D. Alcohol 40-2 Anhydrous			0.00	14.90	1.49
Propane/Iso-butane (A-46)		8.00	0.80		0.00
TOTAL	10.00	8.00	0.80	92.00	9.20
Hair Mousse - 2 (1)	10.00				
Polyquaternium 11			0.00	1.32	0.13
Polyquaternium 4			0.00	1.00	0.10
Silicone			0.00	0.15	0.02
Lexein CP-125			0.00	0.20	0.02
Lexein S620			0.00	0.14	0.01
Aloe Vera			0.00	0.05	0.01
PEG-150			0.00	0.26	0.03
Quaternium 52			0.00	0.20	0.02
Polysorbate 20			0.00	0.05	0.01
Deionized Water			0.00	85.42	8.54
Fragrance			0.00	0.21	0.02
S.D. Alcohol 40-2 Anhydrous			0.00	3.00	0.30
Propellant BIP-55		8.00	0.80		0.00
TOTAL	10.00	8.00	0.80	92.00	9.20
Hair Lusterizer - 1 (1)	10.00				
Isodecyl Oleate			0.00	5.00	0.50
Odorless Mineral Spirits			0.00	35.00	3.50
Mink Oil			0.00	0.10	0.01
Fragrance			0.00	0.10	0.01
S.D. Alcohol 40-2 Anhydrous			0.00	19.80	1.98
Propane/Iso-butane (A-46)		40.00	4.00		0.00
TOTAL	10.00	40.00	4.00	60.00	6.00

TABLE H-6. MEDICINAL AND PHARMACEUTICAL FORMULATIONS

	Average Product Weight	Propellant		Other	
Product Formula	oz.	%	oz.	%	oz.
Beta-Adrenergic Bronchodilator Formula (1)	0.50				
Terbutaline Sulfate			0.00	0.71	0.00
Sorbitan Trioleate			0.00	1.00	0.01
CFC-11		24.57	0.12		0.00
CFC-114		24.57	0.12		0.00
CFC-12		49.14	0.25		0.00
TOTAL	0.50	98.29	0.49	1.71	0.01
Vaginal Contraceptive Mousse (1)	2.50				
Nonxynol 9			0.00	8.00	0.20
Lauric/Myristic Acids			0.00	2.50	0.06
Stearic/Palmitic Acids			0.00	3.50	0.09
Triethanolamine			0.00	2.20	0.06
Glyceryl Monostearate			0.00	2.50	0.06
Polyoxyethylene (20)			0.00		0.00
Sorbitan Mono-oleate			0.00	2.50	0.06
Polyoxyethylene (20)			0.00		0.00
Sorbitan Mono-laurate			0.00	3.50	0.09
Polyethylene 600 Glycol			0.00	1.50	0.04
Polyvinylpyrrolidone K-30			0.00	1.00	0.03
Benzethonium Chloride, USP			0.00	0.20	0.01
Deionized water			0.00	67.60	1.69
Propellant A-46		5.00	0.13		0.00
TOTAL	2.50	5.00	0.13	95.00	2.38

TABLE H-7. HOUSEHOLD CLEANER FORMULATIONS

Product Formula	Average Product Weight oz.	Propellant		Other	
		%	oz.	%	oz.
Oven Cleaner - 1 (1)	12.00				
Sodium Hydroxide			0.00	5.00	0.60
Sodium Nitrite			0.00	0.20	0.02
Triethanolamine - 99%			0.00	1.00	0.12
Tetrosodium EDTA - 38%			0.00	1.00	0.12
Deionized Water			0.00	87.80	10.54
Iso-butane (A-31)		5.00	0.60		0.00
TOTAL	12.00	5.00	0.60	95.0	11.40
Oven Cleaner - 2 (1)	12.00				
Potassium Formate			0.00	6.00	0.72
Potassium Acetate			0.00	6.00	0.72
Calcium Dodecylbenzene Sulfonate			0.00	3.00	0.36
Compatible Thickener			0.00	0.50	0.06
Sodium Nitrite			0.00	0.20	0.02
Deionized Water			0.00	78.30	9.40
Iso-butane (A-31)		6.00	0.72		0.00
TOTAL	12.00	6.00	0.72	94.00	11.28
Rug & Carpet Cleaner Product (1)	20.00				
Sodium Lauryl Sulfate (Very low in Chloride)*			0.00	1.60	0.32
Magnesium Lauryl Sulfate (Very low in Chloride)**			0.00	1.20	0.24
Sodium Lauryl Sarkosinate 30% in water***			0.00	3.00	0.60
Styrene Maleic Anhydride Copolymer 15% in water			0.00	20.00	4.00
Optical Brightener; as Calcofluor SD (Optional)			0.00	0.02	0.00
Ammonium Hydroxide (28% NH3 in water)			0.00	0.16	0.03
Fragrance			0.00	0.08	0.02
Deionized Water			0.00	66.44	13.29
Iso-butane A-31		7.50	1.50		0.00
TOTAL	20.00	7.50	1.50	92.50	18.50

(Continued)

TABLE H-7. (Continued)

Product Formula	Average Product Weight oz.	Propellant		Other	
		%	oz.	%	oz.
Window Cleaner - 1 (1)	12.00				
Isopropanol - 99%			0.00	4.00	0.48
Propylene Glycol Monoethyl Ether			0.00	3.00	0.36
Ammonium Lauryl/Myristyl Alcohol			0.00	0.20	0.02
Sodium Nitrite			0.00	0.10	0.01
Ammonia (29% NH3 in water)			0.00	0.20	0.02
Deionized water			0.00	89.00	10.68
Iso-butane A-31		3.50	0.42		0.00
TOTAL	12.00	3.50	0.42	96.50	11.58
Window Cleaner - 2 (1)	12.00				
Isopropanol - 99%			0.00	5.00	0.60
Propylene Glycol Monoethyl Ether			0.00	2.50	0.30
Sodium Lauryl Sulfate			0.00	0.20	0.02
Lauryl Di-isopropanolamide			0.00	0.10	0.01
Sodium Nitrite			0.00	0.20	0.02
Ammonia (29% NH3 in water)			0.00	0.20	0.02
Deionized water			0.00	88.50	10.62
Iso-butane A-31		3.30	0.40		0.00
TOTAL	12.00	3.30	0.40	96.70	11.60
Window Cleaner - 3 (1)	12.00				
Isopropanol - 99%			0.00	4.00	0.48
Butoxyethanol			0.00	2.00	0.24
Lauryl Di-isopropanolamide			0.00	0.10	0.01
Ammonium Lauryl/Myristyl Alcohol			0.00	0.10	0.01
Sodium Nitrite			0.00	0.10	0.01
Ammonia (29% NH3 in water)			0.00	0.20	0.02
Deionized water			0.00	90.00	10.80
Iso-butane A-31		3.50	0.42		0.00
TOTAL	12.00	3.50	0.42	96.50	11.58

(Continued)

TABLE H-7. (Continued)

Product Formula	Average Product Weight oz.	Propellant %	Propellant oz.	Other %	Other oz.
Disinfectant Cleaner - (1)	12.00				
Sodium meta-Silicate 5-Hydrate			0.00	0.10	0.00
Tetrasodium EDTA (38% A.I. in Water)****			0.00	4.12	0.50
BTC 2125M (50% A.I. in Water)			0.00	0.40	0.04
Sodium Benzoate			0.00	0.10	0.01
Sodium Tetraborate 10-Hydrate			0.00	0.10	0.01
Morpholine			0.00	0.20	0.02
Ammonium Hydroxide (29% NH3 in water)			0.00	0.10	0.13
Atlas G-3821 Non-ionic Surfactant*****			0.00	0.50	0.06
Butyl Cellosolve			0.00	6.00	0.72
Potassium Hydroxide (45% A.I. in Water)			0.00	0.05	0.01
Fragrance			0.00	0.15	0.02
Deionized water			0.00	80.18	9.62
Iso-butane A-31		7.00	0.84		0.00
TOTAL	12.00	7.00	0.84	93.00	11.16

* As Maprofix 563, by the Onyx Division of Witco Chemical Co.

** As Maprofix Mg.

*** As Maprosil 30.

**** Tetrasodium Ethylenediamine-tetraacetate, such as Cheelox BF-13, or Versene 30 (Dow).

***** By ICI America, Inc.

TABLE H-8. ROOM DEODORANT/DISINFECTANT FORMULATIONS

Product Formula	Average Product Weight oz.	Propellant		Other	
		%	oz.	%	oz.
Air Freshener - 1 (1)	8.00				
Fragrance			0.00	1.00	0.08
Odorless Petroleum Distillates			0.00	6.28	0.50
Lampolamide 5 Liquid (Croda)			0.00	0.72	0.06
Sodium Benzoate			0.00	0.15	0.01
Deionized water			0.00	59.85	4.79
Propellant A-60		32.00	2.56		0.00
TOTAL	8.00	32.00	2.56	68.00	5.44
Air Freshener - 2 (1)	8.00				
Fragrance			0.00	1.50	0.12
Propellant A-60		90.00	7.20		0.00
Dimethyl Ether		8.50	0.68		0.00
TOTAL	8.00	98.50	7.88	1.50	0.12
Air Freshener - 3 (1)	8.00				
Fragrance			0.00	2.00	0.16
Odorless Petroleum Distillates			0.00	6.00	0.48
S.D. Alcohol 40-2 (Anhydrous)			0.00	38.00	3.04
Deionized water			0.00	4.00	0.32
Propellant A-60		50.00	4.00		0.00
TOTAL	8.00	50.00	4.00	50.00	4.00
Room Disinfectant - 1 (1)	8.00				
o.Phenyl-phenol (95% purity)			0.00	0.11	0.01
S.D. Alcohol 40-2 (Anhydrous)			0.00	73.38	5.87
Fragrance			0.00	0.11	0.01
Sodium Benzoate			0.00	0.20	0.02
Morpholine			0.00	0.20	0.02
Deionized water			0.00	21.00	1.68
Carbon Dioxide		5.00	0.40		
TOTAL	8.00	5.00	0.40	95.00	7.60

(Continued)

TABLE H-8. (Continued)

Product Formula	Average Product Weight oz.	Propellant %	Propellant oz.	Other %	Other oz.
Room Disinfectant - 2 (1)	8.00				
BTC-2125M (50% in Water)			0.00	0.28	0.02
Atlas G-271 (35% in Water)			0.00	0.12	0.01
S.D. Alcohol 40-2 (Anhydrous)			0.00	52.07	4.17
Fragrance			0.00	0.11	0.01
Sodium Benzoate			0.00	0.22	0.02
Morpholine			0.00	0.20	0.02
Deionized water			0.00	25.00	2.00
Propellant Blend A-40		22.00	1.76		0.00
TOTAL	8.00	22.00	1.76	78.00	6.24

TABLE H-9. LAUNDRY AID FORMULATIONS

Product Formula	Average Product Weight oz.	Propellant		Other	
		%	oz.	%	oz.
Pre-laundry Cleaners - 1 (1)	16.00				
Linear primary or secondary alcohol polyglycol ether (2-4 mol ETO)			0.00	12.00	1.92
Linear primary or secondary alcohol polyglycol ether (7-10 mol ETO)*			0.00	12.00	1.92
Diethylene Glycol Monomethyl Ether			0.00	12.00	1.92
Sodium Laurate/Myristate			0.00	0.40	0.06
Isopropanol - 99%			0.00	4.00	0.64
Low-odor n.Paraffinic or iso.Paraffinic Solvent (C10-C14 hydrocarbons)			0.00	20.00	3.20
Ammonium Hydroxide (28% NH3 in water)			0.00	0.50	0.08
Fragrance (Typically lemon/lime)			0.00	0.50	0.08
Enzyme Concentrate (Optional)			0.00	1.00	0.16
Deionized Water			0.00	30.10	4.82
Propane A-108 or Propellants A-85		7.50	1.20		0.00
TOTAL	16.00	7.50	1.20	92.50	14.80
Pre-laundry Cleaners - 2 (1)	16.00				
Linear primary or secondary alcohol polyglycol ether (7-10 mol ETO)*			0.00	10.00	1.60
Diethylene Glycol Monomethyl Ether			0.00	5.00	0.80
Isopropanol - 99%			0.00	5.00	0.80
Low-odor n.Paraffinic or iso.Paraffinic Solvent (C10-C14 hydrocarbons)			0.00	76.70	12.27
Fragrance (Typically lemon/lime)			0.00	0.50	0.08
Carbon Dioxide		2.80	0.45		0.00
TOTAL	16.00	2.80	0.45	97.20	15.55
Spray Starch - 1 (1)	16.00				
Amaizo No. 513 Pearl Starch			0.00	2.30	0.37
Sodium Tetraborate 10-Hydrate			0.00	0.30	0.05
Silcone Emulsion LE-463,346 or equal			0.00	0.40	0.06
Silcone Antifoam Emulsion			0.00	0.15	0.02
Sodium Nitrite or Sodium Benzoate			0.00	0.15	0.02
Fragrance			0.00	0.02	0.00
Glutaraldehyde (50%) or			0.00		0.00
Formaldehyde (37% in Water)			0.00	0.04	0.00
Optical Brightener			0.00	0.02	0.00
Deionized Water			0.00	91.10	14.58
Iso-butane		5.50	0.88		0.00
TOTAL	16.00	5.50	0.88	94.50	15.12

(Continued)

TABLE H-9. (Continued)

Product Formula	Average Product Weight oz.	Propellant %	Propellant oz.	Other %	Other oz.
Spray Starch - 2 (1)	16.00				
Penford Gum 290 or Equilvalent			0.00	2.75	0.44
Sodium Tetraborate 10-Hydrate			0.00	0.40	0.06
Silcone Emulsion LE-463,346 or equal			0.00	0.50	0.08
Silcone Antifoam Emulsion			0.00	0.10	0.02
Fragrance			0.00	0.03	0.00
Glutaraldehyde (50%) or Formaldehyde (37% in Water)			0.00	0.06	0.00
Deionized Water			0.00	90.16	14.43
Iso-butane		6.00	0.96		0.00
TOTAL	16.00	6.00	0.96	94.00	15.04
Spray Starch - 3 (1)	16.00				
EO-Size 5795 Starch or Equivalent			0.00	3.00	0.48
Sodium Tetraborate 10-Hydrate			0.00	0.45	0.07
Silcone Emulsion LE-463,346 or equal			0.00	0.44	0.07
Silcone Antifoam Emulsion			0.00	0.10	0.02
Sodium Nitrite or Sodium Benzoate			0.00	0.10	0.02
Fragrance			0.00	0.03	0.00
Glutaraldehyde (50%) or Formaldehyde (37% in Water)			0.00	0.04	0.01
Deionized Water			0.00	90.00	14.40
Iso-butane		5.84	0.93		0.00
TOTAL	16.00	5.84	0.93	94.16	15.07
Absorbent Silica Cleaner - (1)	7.00				
Fumed Silica Powder			0.00	6.00	0.42
1,1,1-Trichloroethane			0.00	68.00	4.76
Isopropanol - 99%			0.00	10.00	0.70
Fragrance			0.00	0.05	0.00
Propane A-108		15.95	1.12		0.00
TOTAL	7.00	15.95	1.12	84.05	5.88

* May be replaced with octyl or nonyl phenol polyoxyethylene (9-13 mol ETO) of other non-ionics of similar HLB value.

TABLE H-10. WAX/POLISH FORMULATIONS

Product Formula	Average Product Weight oz.	Propellant		Other	
		%	oz.	%	oz.
Furniture Polish - 1 (1)	14.00				
Wax S and Wax N (1:1 ratio) Hoechst			0.00	1.25	0.18
Silicone Emulsion LE-461 (50% A.I.) UCC			0.00	1.40	0.20
Silicone Emulsion LE-462 (50% A.I.) UCC			0.00	0.35	0.05
Arlacel C (Non-ionic surfactant) ICI Am.			0.00	0.15	0.02
Isopar C or E			0.00	2.00	0.28
Lemon Oil, Technical Grade			0.00	0.75	0.11
Glutaraldehyde (50% A.I.) UCC			0.00	0.05	0.01
Sodium Nitrite			0.00	0.05	0.01
Deionized Water			0.00	87.00	12.18
Iso-butane A-31		7.00	0.98		0.00
TOTAL	14.00	7.00	0.98	93.00	13.02
Furniture Polish - 2 (1)	14.00				
Wax S and Wax N (1:1 ratio) Hoechst			0.00	1.25	0.18
Silicone Emulsion LE-461 (50% A.I.) UCC			0.00	1.40	0.20
Silicone Emulsion LE-462 (50% A.I.) UCC			0.00	0.35	0.05
Arlacel C (Non-ionic surfactant) ICI Am.			0.00	1.25	0.18
Isopar C or E			0.00	33.00	4.62
Lemon Oil, Technical Grade			0.00	0.60	0.08
Glutaraldehyde (50% A.I.) UCC			0.00	0.03	0.00
Sodium Nitrite			0.00	0.05	0.01
Deionized Water			0.00	44.57	6.24
Iso-butane A-31		17.50	2.45		0.00
TOTAL	14.00	17.50	2.45	82.50	11.55

(Continued)

TABLE H-10. (Continued)

Product Formula	Average Product Weight oz.	Propellant		Other	
		%	oz.	%	oz.
Wood Panel Polish (1)	14.00				
D. C. 536 Fluid*			0.00	2.00	0.28
D. C. 200 Fluid**			0.00	2.00	0.28
Witcamide 511 - Witco Chem. Co.			0.00	1.00	0.14
Isopar L and/or Isopar M - Exxon			0.00	26.50	3.71
Isopar K - Exxon			0.00	65.20	9.13
Fragrance			0.00	0.05	0.01
Isopropanol (Anhydrous)			0.00	0.25	0.04
Carbon Dioxide		3.00	0.42		0.00
TOTAL	14.00	3.00	0.42	97.00	13.58

* An aminofunctional polydimethyl-siloxane copolymer - Dow Corning Corporation

** Dimethylsiloxane polymer - Dow Corning Corp. (12,500 cstks)

TABLE H-11. MAJOR AUTOMOTIVE/INDUSTRIAL PRODUCT FORMULATIONS

Product Formula	Average Product Weight oz.	Propellant %	Propellant oz.	Other %	Other oz.
Spray Lubricant (2)	14.00				
Mineral Oils			0.00	90.00	12.60
Isobutylene polymers			0.00	5.00	0.70
Propellant		5.00	0.70		0.00
TOTAL	14.00	5.00	0.70	95.00	13.30
Carburetor/Choke Cleaner (2)	12.00				
Aliphatic/Aromatic Hydrocarbons (e.g., Toluene, Acetone)			0.00	88.00	10.56
Butane		12.00	1.44		0.00
TOTAL	12.00	12.00	1.44	88.00	10.56
Engine Starting Fluid (1)	8.96				
Diethyl ether			0.00	91.00	8.15
Carbon Dioxide		9.00	0.81		0.00
TOTAL	8.96	9.00	0.81	91.00	8.15
Rotary Tablet Machine Die Lubricant - 1 (1)	14.00				
Lecithin			0.00	2.00	0.28
Sorbitan Trioleate			0.00	0.50	0.07
Ethanol (Anhydrous)			0.00	2.50	0.35
CFC-113			0.00	70.00	9.80
CFC-12		25.00	3.50		0.00
TOTAL	14.00	25.00	3.50	75.00	10.50

TABLE H-12. FORMULATIONS FOR MISCELLANEOUS AUTOMOTIVE/INDUSTRIAL AEROSOLS

Product Formula	Average Product Weight oz.	Propellant %	Propellant oz.	Other %	Other oz.
Gasket Adhesive (1)	16.00				
Isopropanol			0.00	10.00	1.60
Resin 80-1211			0.00	5.00	0.80
Stabilite Ester Number 3			0.00	5.00	0.80
Methylene Chloride			0.00	50.00	8.00
Xylenes			0.00	10.00	1.60
Propellant Blend A-70		20.00	3.20		0.00
TOTAL	16.00	20.00	3.20	80.00	12.80
Brake Cleaner (3)	18.10				
Alcohol (methanol or ethanol) or chlorinated solvents-propellant not specified			0.00	100.00	18.10
TOTAL	18.10	0.00	0.00	100.00	18.10
Spray Undercoating (2)	12.00				
Pigment			0.00	50.00	6.00
Propellant (unspecified non-CFC VO)		25.00	3.00		0.00
Solvent (unspecified non-CFC VO)			0.00	25.00	3.00
Total	12.00	25.00	3.00	75.00	9.00
Tire Inflator/Sealant (4)	11.00				
Unspecified non-CFC VOs (One "active"ingredient also serves as propellant)			0.00	100.00	11.00
Total	11.00	0.00	0.00	100.00	11.00

(Continued)

TABLE H-12. (Continued)

Product Formula	Average Product Weight oz.	Propellant		Other	
		%	oz.	%	oz.
Vinyl/Upholstery Cleaner (1)	18.00				
Sodium Lauroyl Sarcosinate (30% A.I. in Water)			0.00	1.50	0.27
Sodium Lauryl Sulfate Powder USP (Cl- free)			0.00	1.55	0.28
Dupanol WAT			0.00	1.10	0.20
Ammonium Hydroxide (26-28%)			0.00	0.09	0.02
Silicone SM-62 General Electric			0.00	0.90	0.16
Perfume			0.00	0.05	0.01
Isopar C Exxon			0.00	2.75	0.50
Sodium meta-Silicate 5-Hydrate			0.00	0.10	0.02
Deionized Water			0.00	85.96	15.47
Propellant Blend A-46		6.00	1.08		0.00
TOTAL	18.00	6.00	1.08	94.00	16.92
Electronic Cleaners (5)	16.00				
CFC-113				75.00	12.00
Propellant (CFC-12)		25.00	4.00		
TOTAL	16.00	25.00	4.00	75.00	12.00
Engine Degreaser (1)	14.00				
Non-ionic Surfactants			0.00	5.00	0.70
Xylenes			0.00	20.00	2.80
Deodorized Kerosene			0.00	72.00	10.08
Carbon Dioxide		3.00	0.42		0.00
TOTAL	14.00	3.00	0.42	97.00	13.58
Windshield De-icer (1)	16.00				
Methanol-Technical Grade			0.00	54.00	8.64
Propylene Glycol - Technical Grade			0.00	18.00	2.88
Deionized Water			0.00	25.00	4.00
Morpholine			0.00	0.10	0.02
Span 80 or Igepal CO-410 Non-ionics			0.00	0.05	0.01
Sodium Benzoate			0.00	0.05	0.01
Carbon Dioxide		2.80	0.45		0.00
TOTAL	16.00	2.80	0.45	97.20	15.55

TABLE H-13. PAINT/PRIMER/VARNISH FORMULATIONS

Product Formula	Average Product Weight oz.	Propellant		Other	
		%	oz.	%	oz.
Paint - Acrylic Metallic (1)	12.00				
Acryloid B72 (50% A.I.)			0.00	8.00	0.96
Acryloid A101 (40% A.I.)			0.00	1.00	0.12
Gold Powder #6238			0.00	4.00	0.48
Propylene Glycol Monomethyl Ether			0.00	2.00	0.24
Nonylphenoxy Polyethoxy Ethanol			0.00	0.10	0.01
Toluene			0.00	28.20	3.38
Xylenes			0.00	12.40	1.49
Acetone			0.00	15.40	1.85
Hydrocarbon Propellant Blend A-85		28.90	3.47		0.00
TOTAL	12.00	28.90	3.47	71.10	8.53
Paint - Acrylic (1)	12.00				
Corboset 514H (40% A.I.)			0.00	25.00	3.00
Tint Aid (Black WD-2350)			0.00	5.00	0.60
Titanium Dioxide Powder (R-940)			0.00	1.00	0.12
Propylene Glycol Monomethyl Ether			0.00	5.00	0.60
Isopropanol			0.00	8.00	0.96
Nonylphenoxy Polyethoxy Ethanol			0.00	0.35	0.04
Fluoroacrylic FC-430 Surfactant			0.00	0.02	0.00
Hi-Sil T-600 (Silica)			0.00	0.14	0.02
Magnesium Aluminum Silicate			0.00	0.30	0.04
De-ionized Water			0.00	10.19	1.22
Dimethyl Ether		45.00	5.40		0.00
TOTAL	12.00	45.00	5.40	55.00	6.60

(Continued)

TABLE H-13. (Continued)

Product Formula	Average Product Weight oz.	Propellant		Other	
		%	oz.	%	oz.
Paint - Alkyd - 1 (1)	12.00				
Tint Aid (Black WD-2350)			0.00	5.00	0.60
Beckosol 13-400 (75% A.I.)			0.00	13.00	1.56
Ammonium Hydroxide (29% NH3)			0.00	1.15	0.14
Titanium Dioxide Powder (R-940)			0.00	2.00	0.24
Propylene Glycol Monomethyl Ether			0.00	5.00	0.60
Isopropanol			0.00	8.00	0.96
Nonylphenoxy Polyethoxy Ethanol			0.00	0.45	0.05
Fluoroacrylic FC-430 Surfactant			0.00	0.02	0.00
Hi-Sil T-600 (Silica)			0.00	0.14	0.02
Magnesium Aluminum Silicate			0.00	0.12	0.01
Drier: Cobalt Hydro Cure II			0.00	0.10	0.01
Drier: Zirconium Cem			0.00	0.08	0.01
De-ionized Water			0.00	19.94	2.39
Dimethyl Ether		45.00	5.40		0.00
	12.00	45.00	5.40	55.00	6.60
Paint - Alkyd - 2 (1)	12.00				
Tint Aid (Black WD-2350)			0.00	5.00	0.60
Beckosol 13-400 (75% A.I.)			0.00	13.00	1.56
Ammonium Hydroxide (29% NH3)			0.00	1.15	0.14
Propylene Glycol Monomethyl Ether			0.00	5.00	0.60
Isopropanol			0.00	8.00	0.96
Nonylphenoxy Polyethoxy Ethanol			0.00	0.50	0.06
Fluoroacrylic FC-430 Surfactant			0.00	0.02	0.00
Hi-Sil T-600 (Silica)			0.00	0.14	0.02
Magnesium Aluminum Silicate			0.00	0.15	0.02
De-ionized Water			0.00	22.04	2.64
Dimethyl Ether		45.00	5.40		0.00
TOTAL	12.00	45.00	5.40	55.00	6.60

TABLE H-14. SPACE INSECTICIDE FORMULATIONS

Product Formula	Average Product Weight oz.	Propellant %	Propellant oz.	Other %	Other oz.
Total Release Insect Fogger - (1)	12.50				
Pyrethrum Extract - 20%			0.00	2.00	0.25
Piperonyl Butoxide; Technical			0.00	1.00	0.13
Pertroleum Distillates			0.00	12.00	1.50
1,1,1-Trichloroethane			0.00	55.00	6.88
Propane A-108		30.00	3.75		0.00
TOTAL	12.50	30.00	3.75	70.00	8.75
Insecticide (2)	14.00				
Pyrethins			0.00	0.25	0.04
Piperonyl butoxide			0.00	0.80	0.11
Petroleum distillates			0.00	1.04	0.15
Inert ingredients (Emulsifier/Corrosion Inhib)			0.00	0.91	0.13
Inert ingredients (Water)			0.00	67.00	9.38
Butane/Isobutane		30.00	4.20		0.00
TOTAL	14.00	30.00	4.20	70.00	9.80

TABLE H-15. RESIDUAL INSECTICIDE FORMULATIONS

Product Formula	Average Product Weight oz.	Propellant		Other	
		%	oz.	%	oz.
Insect Repellent (6)	14.00				
n,n-dimethyl-m-toluamide			0.00	19.00	2.66
Other isomers			0.00	1.00	0.14
2,3,4,5-bis-(2-butylene) tetrahydro-2-furaldehyde			0.00	1.00	0.14
n-octyl dicycloheptene dicarboximide			0.00	4.00	0.56
Inerts (alcohol and propellant)		30.00	4.20	45.00	6.30
TOTAL	14.00	30.00	4.20	70.00	9.80
Ant and Roach Killer (6)	11.00				
d-trans-Allethrin			0.00	0.05	0.01
Piperonyl butoxide			0.00	0.10	0.01
N-Octyl dicycloheptene dicarboximide			0.00	0.17	0.02
0-Isopropoxyphenyl methyl carbonate			0.00	0.50	0.06
Petroleum distillate			0.00	86.25	9.49
Propellant		12.90	1.42		0.00
TOTAL	11.00	12.90	1.42	87.07	9.58

TABLE H-16. MAJOR FOOD PRODUCTS FORMULATIONS

Product Formula	Average Product Weight oz.	Propellant %	Propellant oz.	Other %	Other oz.
Whipped Cream (7)	11.00				
Synthetic Dairy Cream			0.00	82.50	9.08
Nitrous oxide		17.50	1.93		0.00
TOTAL	11.00	17.50	1.93	82.50	9.08
Frypan Spray (7)	6.00				
Corn oil, grain alcohol, lecithin			0.00	69.00	4.14
Propellant		31.00	1.86		0.00
TOTAL	6.00	31.00	1.86	69.00	4.14

TABLE H-17. ANIMAL PRODUCTS FORMULATION

Product Formula	Average Product Weight oz.	Propellant %	Propellant oz.	Other %	Other oz.
Flea and Tick Spray for Dogs - (6)	7.00				
2-chloro-1(2,3,5-trichlorophenyl) vinyl dimethyl phosphate			0.00	0.99	0.07
Inerts (incl. propellant)		5.00	0.35	94.01	6.58
TOTAL	7.00	5.00	0.35	95.00	6.65

REFERENCES FOR APPENDIX H

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2. Jones, A., H. Rich, G. Sewell, M. Rogozen, and M. Katz. Photochemically Reactive Organic Compound Emissions (NTIS PB88-216940).* U.S. Environmental Protection Agency, Region 2, New York, NY, November 26, 1986. (*) EPA-902/4-86-001.

3. Examination of brake cleaners at a local auto supply store, Radian Corporation, Austin, TX, June 1989.

4. Examination of tire sealant at local auto parts store, Radian Corporation, Austin, TX, September 1988.

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7. Johnsen, Montfort A. The Aerosol Handbook, Second Edition. Dorland Publishing Company, Mendham, NJ, 1982.